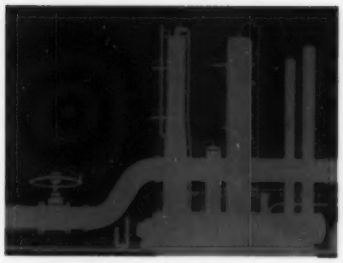

A SPECIAL REPORT

NATURAL GASOLINE

New developments in old plants, CO_2 removal and boiler maintenance p.123

OIL, GAS AND PETROCHEMICAL PROCESSING

Petroleum Refiner

APRIL
1960

NEW DATA

How Isocracking Process Works 155

BETTER YIELDS

Simulate Refinery on Computer 169

COST SAVER

How Tubes Affect Heater Design 177

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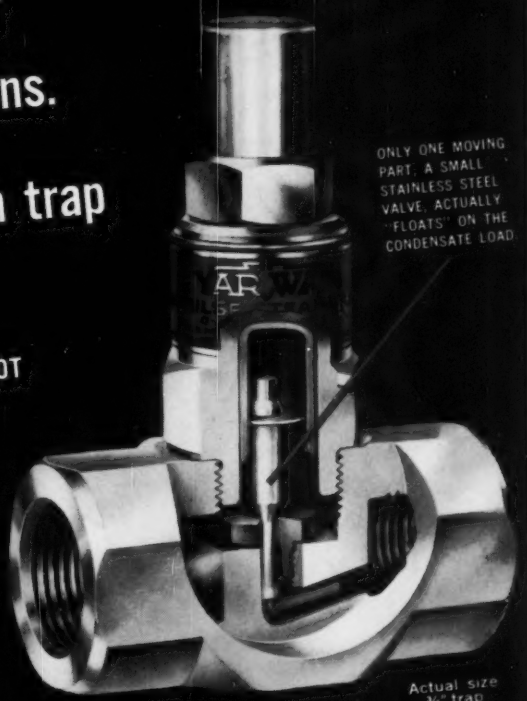

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Volume 39, No. 4 April 1960

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Petroleum
Refiner
OIL, GAS AND PETROCHEMICAL PROCESSING

A Gulf Publishing Company Publication

A Quick Look
at This Issue

These handy digests permit checking ☑ the articles you want to read first.

SPECIAL REPORT ON NATURAL GASOLINE

☐ **How to Increase C_3 and C_4 Recovery . . .** Most older plants can increase propane and butane recovery by following the nine methods outlined by this process engineer. Some are cheap operational changes, while others require major equipment additions. You'll get the full story by turning to **Page 124.**

☐ **New Data on Hot Carbonate Process . . .** Capital costs and steam requirements can be reduced, according to this new data just released by Bureau of Mines experts, Benson and Field. Here you'll find commercial plant data from five sources compared to pilot plant studies. For better design of new plants, see **Page 127.**

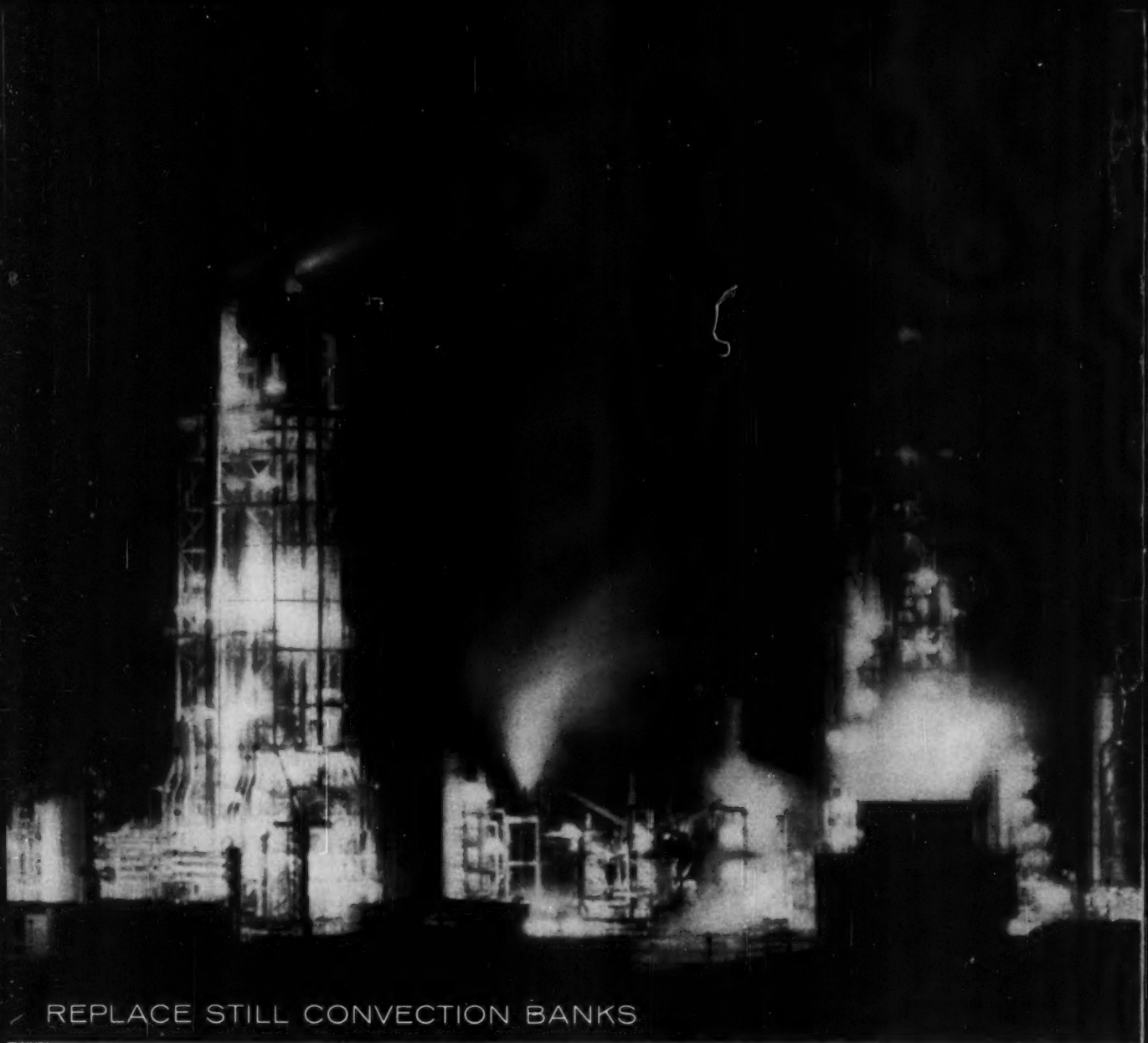
☐ **Operator's Handbook for Gasoline Plants . . .** This part on orifice meters explains the most common instrument an operator has to deal with. How to install orifice meters and how to calculate the flow are two of the important items covered. Continue this highly informative series by turning to **Page 133.**

☐ **Better Steam Boiler Maintenance . . .** Only a modern maintenance program can capitalize on today's steam boiler efficiency. You'll get a great deal out of this practical guide to cleaning, repair and preventive maintenance. Turn now to **Page 139.**

☐ **Gulf HDS Turns Resid Into Cat Feed . . .** Now Gulf changes emphasis for HDS process. As a result, atmospheric and vacuum residues can be converted into catalytic cracking feeds which are equal or superior to virgin gas oils. You'll see how it is possible to completely eliminate residual fuel production from a refinery. And equally important, you'll get all the economics for the process . . . so turn now to **Page 143.**

☐ **Radiograph Welds and Cut Vessel Costs . . .** Higher welded joint efficiencies are allowed by the ASME Unfired Pressure Vessel Code. Therefore, you can use thinner shells and heads if the vessel is

Please Turn Page ➔



REPLACE STILL CONVECTION BANKS

WITH A **LJUNGSTROM® AIR PREHEATER**

You can make major economies in the refining of corrosive crudes, or in any refining that involves very high temperatures, by replacing still convection banks with a Ljungstrom Air Preheater. This is how.

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These extra savings can be almost pure profit, because you will probably save enough by eliminating or reducing convection banks to pay the cost of an Air Preheater installation.

Here's documented evidence. One company's fuel savings with a Ljungstrom Air Preheater are factually described in a published magazine article by O. F. Campbell. A reprint of this case history is yours free. Simply write to Air Preheater Corp.

THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N. Y.

A Quick Look at This Issue . . .

radiographed. This article tells you what to look for in an X-ray or Gamma ray radiograph and the defects requiring rejection as defined by the code. For complete details turn to **Page 149.**

☐ **Compressibility Factors for Propane and for Methylacetylene at Low Pressures . . .** Second virial coefficients and low pressure compressibility factors are shown here for pressures up to 2 atm and temperature range of —30 to +75° C. The data are within 0.04% of the true values. See **Page 151.**

☐ **How Isocracking Works . . .** Reactions in this new process are very unusual and explain the five typical uses in the refinery. This process compliments both catalytic reforming and catalytic cracking. You'll get the full story by turning to **Page 155.**

☐ **Confirm Trace Component Identity . . .** At times, trace component identification eludes research and analytical methods. When this happens, you can apply engineering methods and plate-to-plate calculations to find the effect these have on column performance. For a method which can improve your distillation column efficiency, turn to **Page 161.**

☐ **Modern Cooling Tower Treatments . . .** A high pH in cooling tower water will practically stop corrosion, but deposits at that level would foul the equipment. Using a low pH in the water will control the deposits but corrosion would eat up the equipment. For details on steps to a balanced treatment program, turn to **Page 165.**

☐ **Simulate Your Refinery on a Computer . . .** Here are some of the points considered by one refiner in setting up a refinery simulation program. See how the computer program can make it easier for you to calculate the best product distribution under varying conditions. Turn now to **Page 169.**

☐ **Automation Today (Part 20) . . .** Here is a more exact graphical method to supplement the rough sketch of a system's response. The response plot is accurate enough now to show you what control system to use. Be sure to keep up with this important development of ways to explore process control techniques. Turn to **Page 173.**

☐ **Tube Location Is Key to Heater Performance . . .** The most important single variable in heater performance is the clearance between the tube-bank and the furnace wall. The results of these tests show that a designer can get improved performance without raising heater costs. You'll want to use these test results in your next design, so turn to **Page 177.**

☐ **Hydrocracking Tried on Larger Scale . . .** Now a commercial size unit is used to crack asphaltic crudes in the presence of hydrogen and a catalyst. The process differs from many other hydrogenation methods by operating at lower temperatures and pressures. This article extends the laboratory and pilot plant data reported earlier, so keep up to date by starting on **Page 182.**

☐ **Steam Turbine Generator Costs . . .** Using these data and the charts included, you can rapidly estimate the total installed costs for this important process utility. Save time now, turn to **Page 185.**

☐ **These Factors Affect Plant Location . . .** In today's changing economics raw materials can become secondary if good regional markets and transportation gateways are available. For a comparison of how these three factors influence plant location, turn to **Page 189.**

☐ **Applied Hydrocarbon Thermodynamics (Part 16). Charts for Integral Method for Equilibrium Vaporization Calculations . . .** Here is a discussion of the integral method plus many charts to help in estimating TBP assays. You'll also find many advantages to using this method. Be sure you see **Page 193.**

☐ **Physical Properties of Liquid Cresoles . . .** is another useful nomogram for quickly picking off properties of all three isomers. Turn to **Page 200.**

☐ **Get Octanes With This Isom Process . . .** Here's the latest word on the Iso-Kel process. This article reports the results of a thorough examination in a small scale isothermal test unit. Now you have information for process designs and can see what isomerization of light straight run material can do for you. Turn now to **Page 201.**

☐ **Five Safer Methods of Chemical Storage . . . Fire Safety Economics: Part 2 . . .** Here's a valuable fire safety rating chart which enables you to compare the different types of storage tanks. There's also some good advice on fire extinguishing techniques and materials. You're going to want to clip this one, put it with Part 1 and keep it for reference. Turn now to **Page 207.**

☐ **Foremen Should Know Labor Contracts . . .** Most employes look to the foreman for proper instructions and supervision. So in order to maintain good labor relations it is necessary for foremen to understand the basics of the Taft-Hartley and the workings of the collective-bargaining procedure. You'll want to read this one carefully—it starts on **Page 211.**

☐ **Phillips Committee Manages Engineers . . .** Through the years as Phillips' Natural Gasoline Department's Operating Division expanded, manpower management problems became more pronounced. Finally a technical personnel committee was formed, and has since transformed an administrative nightmare into a smooth functioning system of technical personnel placement. You'll want to be sure to read this highly interesting and informative article, so turn now to **Page 215.**

CROUSE/HINDS

Condulet®
electrical equipment

the one complete line for corrosive locations

Photo shows Feraloy Condulet conduit fitting after several years exposure to hydrochloric acid. Note extreme deterioration of conduit.

RESISTS chemical and galvanic corrosion

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RESISTS varying concentrations and temperatures of corrosive liquids, vapors, gases, dusts

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Refine Our Manners

Actually, this discussion should have found a spot on this page in the issue dated January, the month when good resolutions show up in the corral. But while most timely then, the idea is worth sharing whether it be March or May.

"Let's make our motoring manners as refined as our gasoline."

That slogan was used in a United States Postal Bulletin last September and after a slight chase we found that it first appeared in a Safe Driver Booklet of the National Safety Council.

It seems so appropriate for use by the oil refining industry that we're tossing it out in hope that some company—or companies—will grab onto it and put it to full use. It is our understanding that the National Safety Council permits free use of its slogans. It's possible, of course, that its wording might be revised slightly and thus better suit an interested company. The Council wouldn't object to that, either.

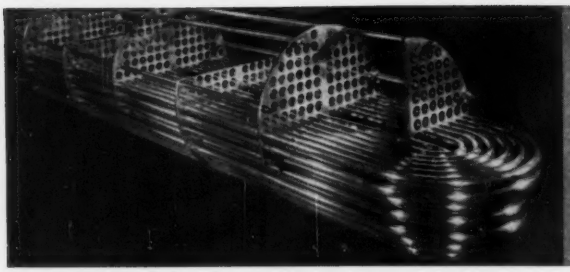
In the meantime, each of us, proud of the sort of gasoline that's being produced nowadays might adopt the slogan as our own and let the thought sort of govern our action when we get behind the wheel.

A Shot in the Arm

IF YOU NOW HOLD a managerial or supervisory position, or if you someday hope to hold such a position, you will be highly interested in a new series of articles beginning next month in PETROLEUM REFINER. These are just the type of articles which every magazine hopes for, but which seldom come along. And as a matter of fact, these didn't just "come along," as they have been in the planning and development stage for more than 14 months. Written by Drs. Robert Blake and Jane Mouton, both of the Psychology department of The Universiy of Texas, this series deals with the subject of "Applied Group Dynamics," an entirely new and different approach to management development. For instance, how does management make decisions and place them into operation? Usually it's by following the traditional approach—through edicts under an authority-obedience power system. However, as you will learn from these articles, there is a much better and more efficient way. Yes, you're going to give your managerial training a big shot in the arm when you start reading "Applied Group Dynamics," in the "As Management Sees It" section of the May issue of PR.

Had It First

THE AIChe is sponsoring a computer program interchange. Best methods of engineering equipment are set up so any processing company with a computer can make the calculations fast. And thus selected for the calculation problem, minimum reflux for distillation, is the Batchelor method, published exclusively in PETROLEUM REFINER, June, 1957.



CONDENSER AND HEAT EXCHANGER CLINIC

Edited by David S. Hibbard, Metallurgical Engineer
The American Brass Company, Buffalo 5, New York

New tube mill equipment gives designer of heat-transfer units freer hand in meeting new trends

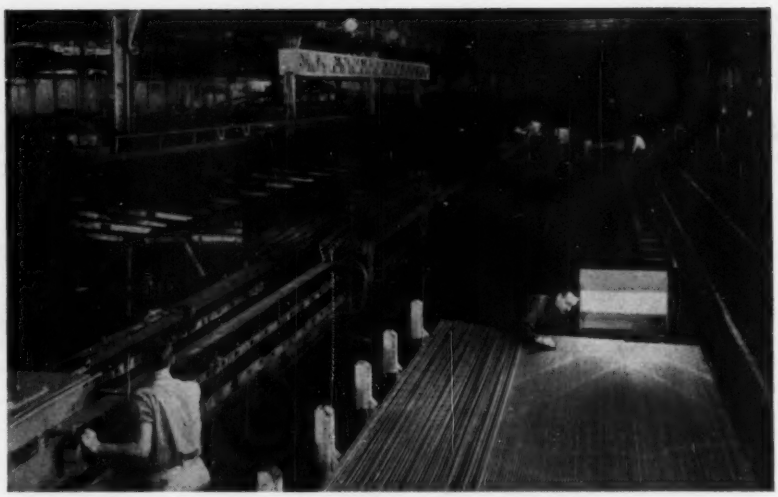
With the installation of new production and testing equipment, The American Brass Company now offers the most complete service available to users of condenser and heat exchanger tubes.

Long lengths. To gain advantages in construction, processing, or installation, designers can lengthen equipment considerably. Tubes can now be drawn up to 100 feet. Most of the longer tubes are required as U-bends, but in some instances may be shipped as straight lengths.

U-bends. Tubes from ⅜" O.D. to 1½" O.D. with wall thicknesses from .049" (18BWG) to .134" (10BWG) can be bent on a radius of from 1¼ times the tube O.D. to 30".

Dual Gage. Where high temperatures and pressures are involved, it may be desirable to thicken the tube wall in the area of short-radius bends on U-bend tubes. Walls are thickened one Stubs' Gage No. to compensate for thinning of metal in the bending.

Thickened Tube Ends. To compensate for thinning by rolling or by impingement corrosion caused by high velocities, tubes may be supplied with the wall thickened at one end one or more Stubs' Gage Nos. The extra thickness may be on the outside or inside of the tube as required.



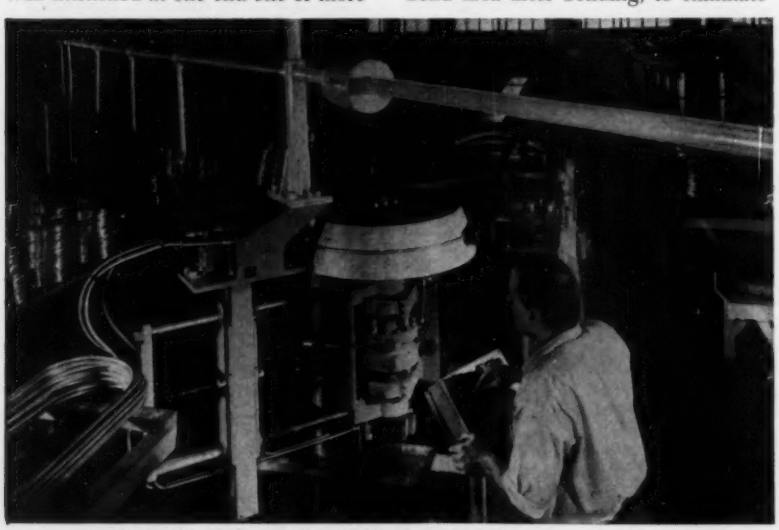
GENERAL VIEW of new American Brass Company equipment which can draw copper and copper alloy tubes in lengths up to 100 feet.

Relieving Stresses. All U-bend tubes, other than copper, are annealed at the bend area after bending, to eliminate the hazard of stress-corrosion cracking which might occur in service due to stresses that may exist as a result of the bending.

Testing. U-bends are tested hydrostatically at ASTM Specification pressures —or at ASME Code pressures up to 6000 psi on request, if the tube size will stand it. Electronic inspection with eddy-current equipment is available also, when required.

Shipping. U-bend tubes are shipped packed for ease in handling and storage.

Technical Assistance. For more detailed information on extra-long tubes, U-bend, Dual-gage, or Duplex tubes to meet special problems, address: The American Brass Company, Buffalo Division, Buffalo 5, New York. In Canada: Anaconda American Brass Limited, New Toronto, Ont. 5057 Rev.



BENDER CAN produce U-bend tubes with straight leg up to 50' long.

ANACONDA®

TUBES AND PLATES FOR CONDENSERS AND HEAT EXCHANGERS

Made by
The American Brass Company

Quick Look at Industry...

Hydrocracking Getting Big Play . . .

More details now available on Unicracking, cat hydrocracking process developed by Union Oil. Similar to Isocracking (see page 155), it converts marginal cracking stocks to high quality gasoline and middle distillates. Also provides new way to upgrade catalytic cycle oil, thermal and coker gas oils, and heavy cracked or straight-run naphthas. Unlike Isocracking, though, it does not recycle other products to extinction when making gasoline.

Cost for 15,000-bpd unit operating at 90% conversion on aromatic gas oil: about $8.4 million—makes direct operating costs in this case 28.1¢ a barrel.

More Runs Being Cut Back . . .

More refiners cutting crude runs, but it's doubtful if the difference will be enough to stem rising inventories. Last month Mobil, Indiana Standard, Conoco, Phillips and D-X Sunray all cut back some, as did Tidewater and Bay Petroleum more recently. According to some estimates, however, refiners will have to cut back by 550,000 bpd and run at only 7.5 million bpd in order to correct present situation. Nation's refiners would then be operating at just 76% capacity.

Sugar Creek Strike Ends Without New Contract . . .

Lacking 4 days of striking 8 months, workers removed pickets from Indiana Standard's Sugar Creek plant after voting to return to work "unconditionally" without a working agreement. Work rules, not wages, are center of controversy—also, union says company's last offer excludes large part of strikers from returning to work because they applied for unemployment or severance compensation. Negotiations are continuing.

More Polypropylene Facilities Coming? . . .

Mitsu Chemical, Tokyo, applies to Bank of Japan and MITI for license to manufacture polypropylene under contract with Montecatini. Makes fifth polypropylene license bid received by MITI. Others applying: Sumitomo Chemical, Nissan Chemical, Tao Nenryo (Standard Vacuum subsidiary) and Showa Denko.

Quick Look Around the Country . . .

Rep. Hechler (D-W. Va.) calls for sweeping Congressional investigation of FPC for failure to protect public interests in face of rising natural gas rates . . . Next 4 annual API meetings all slated for Chicago, thus ruling out West Coast possibilities . . . Humble Oil extends marketing operations to Ohio—may use area to test new brand name . . . OCAW claims membership increased 6.5% since March, 1955 . . . Senator Morse (D.-Ore.) urges U.S. loans to Latin American government oil projects—believes U.S. oil blocked such loans in the past.

New Market for Toluene . . .

Toluene producers interested in recent announcement by Dow to build 36 million lb.-a-year phenol plant using toluene as starting material. Long in oversupply (207 million gallons in '58) toluene has been

difficult to move—but Dow's new phenol process should strengthen market, particularly in areas short on benzene. Also, there is price advantage—toluene sells for about 21¢ a gallon; benzene, 32¢.

U. S. Eyes Helium Program . . .

Undersecretary of State Bennett urges swift Congressional action to establish long-range helium conservation program—says it's "needed to check the waste of this essential gas." Proposal calls for 12 extraction plants on natural gas lines. If build by private enterprise, government would enter long-range agreements to buy helium. Federal government now uses about 90% of helium produced—conserved helium could be stored in government-owned gas field near Amarillo, Texas.

In response to numerous industry requests, Interior released report giving costs of building and operating BuMine's 2 largest helium plants.

Quick Look at World-Wide Construction . . .

One of the world's largest delayed coking units (9,300 bpd) now on stream at Mobil's Torrance, Calif. plant . . . Electro-Chemical, Tokyo carbide concern, planning $80 million petrochemical plant adjoining Maruzen Oil refinery south of Tokyo. Will produce range of petrochemicals including chloroprene and polyethylene—due on stream in '63 . . . Phillips Chemical to further expand at Sweeny with new plant. Present plant now being expanded to 290 million lbs. ethylene yearly—new plant will double that . . . Shell of Canada begins engineering studies for new refinery at Rockeyview, outside Alberta—will produce gasoline and heating oil for Alberta market . . . New propylene plant at Sun's Marcus Hook refinery has potential capacity of 120 million lbs. annually of 99.9% pure product—supposedly country's largest.

British Hiking Russian Trade . . .

Reliable reports claim British manufacturers considerably increasing trade with Russia and other eastern European countries in recent months. Latest plans are for Imperial Chemical Industries to supply know-how to consortium representing Poland, East Germany, Czechoslovakia and Rumania. Company previously signed agreement with Poland to supply polyester fibre and technical information—more recently closed similar deal with Czechoslovakia.

Two New Companies Form . . .

Transcontinental Gas Pipe Line and Jefferson Lake Sulphur go 50-50 in Trans-Jeff Chemical to build and operate plant near Tilden, McMullen County, Texas. Will recover sulfur from waste acid gas stream at Transco's Tilden gas plant—also studying possible manufacture of other chemical products.

Richfield Oil and Witco Chemical form Witfield Chemical to build and operate $1.75 million dodecyclbenzene plant adjacent to Richfield's Watson refinery—on stream date slated for early '61.

Panning the Octane Picture . . .

Premium on sale at service stations average 99.5 F-1 octane last month for a 0.2 jump over February. Regular averaged 92.4 for an increase of 0.1. Looking back for a year, premium rose 0.4 octane over March '59, while regular recorded a 0.7 increase for the 12-month period.

New Model for Coking . . .

Esso R & E has new version of fluid coking—promises to cut installation and operating cost by one-third of that required for 1953 model. Known as Model II Fluid Coking, unit is more compact—requires smaller plot area.

UNRETOUCHED ACTION PHOTOS PROVE SUPERIOR PERFORMANCE OF BUELL CYCLONES

an ordinary cyclone

THE BUELL CYCLONE
with Shave-Off

These are photographs of as true a test as can be made under laboratory conditions. Notice the difference in the dust patterns! In the Buell Cyclone, on the left, the dust at the top makes less than one revolution before it is trapped by the Shave-Off. It's then channeled down to the lower portion of the Cyclone, well below the clean gas outlet.

Why is the Buell Shave-Off so effective? Primarily because it harnesses the double-eddy current to convey the dust "fines" downward quickly, thereby promoting greatly increased efficiencies. In the ordinary cyclone, as shown on the right, these "fines" concentrate and recirculate at the top, causing erosion of the cyclone. To be collected, the fine dust must travel downward close to the clean gas outlet where much of it escapes. Buell Cyclones have made an impressive record in many years of trouble-free service. To see how their extra efficiency in the Shave-Off can pay off for you, send for our Cyclone Catalog #103. The Buell Engineering Co., Inc., 123 William Street, New York 38, New York. Northern Blower Division, 6404 Barberton Avenue, Cleveland, Ohio. (Subsidiary: Ambuco Ltd., London, England.)

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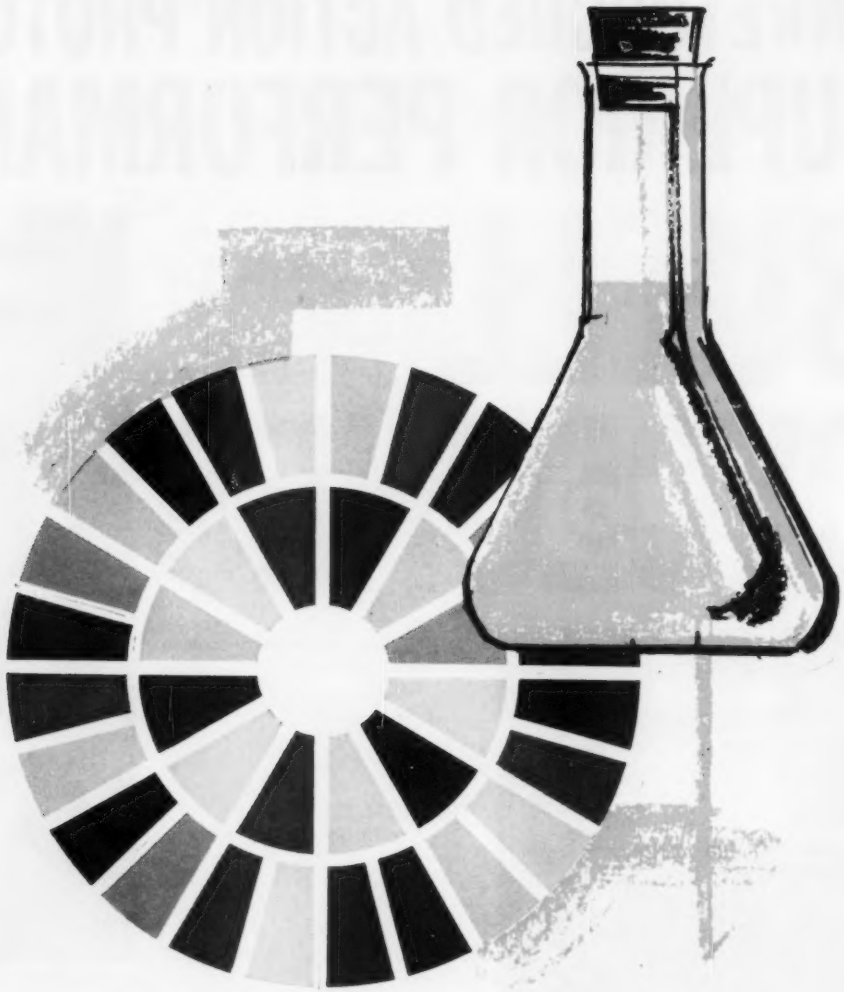

"Ethyl" oil soluble dyes . . . backed by complete technical service

Ethyl offers oil soluble dyes in a full range of colors in all forms—beaded, flaked, powdered and liquid concentrates.

All "Ethyl" dyes are backed by complete technical services based on 37 years of experience in supplying dyes to the petroleum industry.

Experienced Ethyl Product Service engineers can help you select the dyes most advantageous for your needs. Further, they will offer technical help in mixing dyes with petroleum products in the most efficient and economical manner.

In situations requiring specialized work, the facilities and technicians of our modern dye laboratory at Baton Rouge are at your service.

"Ethyl" dyes are constantly being tested at this laboratory to insure their meeting rigid requirements for hue, intensity, solubility, rate and ease of solution, stability in finished gasoline, physical properties and chemical composition.

For samples, fact sheets and a new, complete brochure on Ethyl's full range of oil soluble dyes, call your Ethyl Representative, or write direct.

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ETHYL CORPORATION OF CANADA LIMITED, TORONTO • **ETHYL USA (EXPORT)** NEW YORK 17, N.Y.

Who Said We Are Sick?

John J. McKetta
Dept. of Chemical Engineering
The University of Texas
Austin, Texas

SOME OF US THINK the United States portion of our HPI (hydrocarbon processing industry) has gone to pot because capital expenditure and expenditures for new equipment are below those values of 1957. What we forget is that even though the expenditure in 1959 was less than in 1957, we still spent more than $1 billion last year for new equipment in the United States alone. In fact this country's capital expenditure in 1959 amounted to $680 million for refining and $710 million for petrochemicals for a total of $1.39 billion. Other industries wish they could be so sick!!

Even though these expenditures are lower than those of 1957 ($950 million for refining and $810 million for petrochemicals for a total of $1.76 billion) there is no other manufacturing industry whose capital expenditure compares with these figures of the HPI industry. As a matter of fact one is astonished when he notices that the entire chemical processing industry (excluding the petrochemical processing since this is part of the HPI) capital expenditure has averaged only slightly more than $600 million per year for the past four years.

Confused Commentators. Most of our pessimistic prophets generally are not familiar with the refining and petrochemical portion of the HPI. They take a look at the prospective increase in the crude oil capacity, then hurry to their typewriters to tell the world of the sad state of the entire oil industry. The result of this is that some of the bankers and other financiers, after reading these reports, are prone to refuse loans to oil men because of the demise of this once great industry. These financiers do not realize that this HPI is still the most progressive, and still has the highest capital expenditure of any manufacturing industry. They do not know, and apparently neither do the prophets, that there is still a tremendous expenditure for new equipment in our industry and that the *refining capacity will double* in the next 20 years or before.

However, even if we do not count this tremendous increase in annual capacity (although close to 200,000 bpd new capacity will be added this year alone) we are still faced with the fact that there will continue to be a terriffic amount of new and specialized equipment added each year. These will be those units which enable refiners to keep up with product improvement and the ever-increasing octane requirements. Just last month John Sabina of DuPont predicted that the octane requirements will climb to 103.5 by 1966—this alone will keep refining capital expenditures at the same extremely high level.

This construction is more closely pinpointed in PETROLEUM REFINER's "Construction Boxscore" beginning on Page 256 of this issue. After looking over this tabulation, you'll see what we've known right along (although apparently these so-called prophets have missed it) that more than 800,000 bpd of new processing is now being planned, engineered or constructed in the United States alone. These processes include 90,000 bpd cracking, 75,000 bpd reforming, 70,000 bpd distillation facilities, 27,500 bpd alkylation facilities, 260,000 bpd treating and other special units which do not necessarily add to the over-all crude handling capacity. Current expenditure for these projects amounts to more than $600 million.

WHAT IS "HPI"?

Since CPI does not adequately describe the interest of those engaged in hydrocarbon processing, we here suggest the phrase of "HPI"—hydrocarbon processing industry. HPI includes petroleum refineries, petrochemical plants and natural gasoline plants. Many of our readers will remember that the front cover of the PETROLEUM REFINER has shown our coverage of the refining, petrochemical and natural gasoline industry since August 1942 and that we were the first magazine to specialize in coverage of the HPI.

Taking into consideration other projects which will be announced later in the year, total capital expenditure for refining in 1960 should top $750 million—a 10 percent increase over '59. But of course this is just for the U.S.—"Construction Boxscore" also shows that the worldwide HPI construction is still rising at a remaarkable rate.

Petrochemicals. Most of the people outside of the HPI are unaware that more than 80 percent of the

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SOLVAY CAUSTIC POTASH

When you start with a more reactive material like Solvay® Caustic Potash, you usually get better results. Many users prefer it to caustic soda because it enables them to produce more soluble reaction products and less viscous solutions.

For example, its high solubility permits liquid end products having high soap concentration. Many heavy-duty liquid detergents would not exist were it not for ingredients derived from caustic potash.

Its high reactivity is also useful in mercaptan extraction and desulfurization of petroleum products. Caustic potash solutions effectively absorb carbon dioxide and hydrogen sulfide in industrial gases. Dry forms are highly hygroscopic, excellent for dehydration.

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SOLVAY branch offices and dealers are located in major centers from coast to coast.

Mail the coupon for samples and *new* Solvay Technical Bulletin crammed with facts, tables, diagrams for applying caustic potash.

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☐ Flake ☐ Small Flake ☐ Solid
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organic chemicals produced in the United States are produced from petroleum (PETROLEUM REFINER, November 1958) or that almost 30 per cent of *all* chemicals produced in the United States are petrochemicals (PETROLEUM REFINER, November, 1959, p. 190). Nor do they know that a huge amount of the petrochemical production comes from the refineries and oil company owned plants. The following table shows some of the information as taken from Katzen (PETROLEUM REFINER, January, 1960, p. 169).

Product	Total Capacity Million Pounds 1958	Total Capacity Million Pounds 1960	Percent Produced From Petroleum	Percent of Total Capacity Produced by Refineries and/or Oil Owned Companies
Aliphatics:				
Ethylene	4800	5600	100	41
Propylene	1900	2300	100	60
Aromatics:				
Benzene	3500	3700	52	52
Toluene	2400	2700	82	82
Xylene	1500	2000	60	92
Styrene	1300	1500	60	12
Polymers:				
Polyethylene	1200	1500	100	15
Polyproylene	20	120	100	45
Inorganic:				
Ammonia	10,000	11,000	95	12
Urea	1300	1700	90	14

You can see, for example, that all of the propylene is produced from petroleum and that 60 percent of the production is from plants owned by oil companies. Notice too that even in the inorganic chemicals, more than 10 percent shown is produced in refineries or oil company owned plants.

Taking a look at capital expenditures for the petrochemical side of this HPI, we can look for an outlay of more than $800 million this year in the United States alone.

Natural Gasoline. Another portion of the great HPI in this country is in the natural gasoline field. Natural gasoline processing will add another $100 million in capital expenditures in 1960.

Who says our HPI is sick?

WE EXPECTED THE UNEXPECTED

Latest Commerce Department survey of the petroleum industry shows that capital expenditures in 1960 will be half way back to the peak of 1957. The large over-all increase is for refining, marketing and transportation, with refining showing the largest advance. Says the *Survey of Current of Business*, "The rise in refinery expenditures is perhaps unexpected since refinery operations rose only slightly last year over 1958, which saw the lowest rate of refinery capacity utilization in the postwar period."

Followup Called For

SINCE THE VINDICATION of the 29 major oil companies at Tulsa in February, there has been a lot said and written to the effect that, "we knew it all the time," "the government never had a chance to begin with" and several other innocuous gems of 20-20 hindsight. Of course, this is all well and good, but what is being left unsaid, and what must now be brought to the surface is the big "how" of the entire farce—more specifically, how was the government able to get an indictment and present a case on evidence so flimsy that it is doubtful if the government attorneys themselves were convinced.

It would indeed be going out on a limb to say that these charges and this whole trial were politically inspired—certainly good Americans in public office wouldn't ask the taxpayers to foot the bill just in order to win a few votes. Would they?

Be that as it may, now is the time for the oil industry to exploit its position. For once the oil industry has come out on top because for once in its young life it decided to strike back instead of just ducking when someone else swung a haymaker. And you know—it's a good feeling. It's a good feeling to be able to look anyone in the face and say, "we won." It isn't often oilmen get that opportunity.

Had Federal Judge Royce H. Savage indicated that his ruling might have been different if the government's lawyers had done this or not done that along some legalistic lines—had the case been lost by these Potomac hopefuls because of some technicality, it would have been one thing. But there was no mistaking the basis for the court's view and pronouncement. After knocking down the house of straw which the Department of Justice had in a devious manner tried to construct, the judge stepped with positiveness on the shabby remains of their case and ground them under his heel with "I think I should go further and simply say that after giving consideration to all of this evidence I have an absolute conviction, personally, that the defendants are not guilty of the charge made in this case."

He had found the government's charges so flimsy that he did not even call upon the oil companies to present their defense but exonerated them in the light of the government's own evidence.

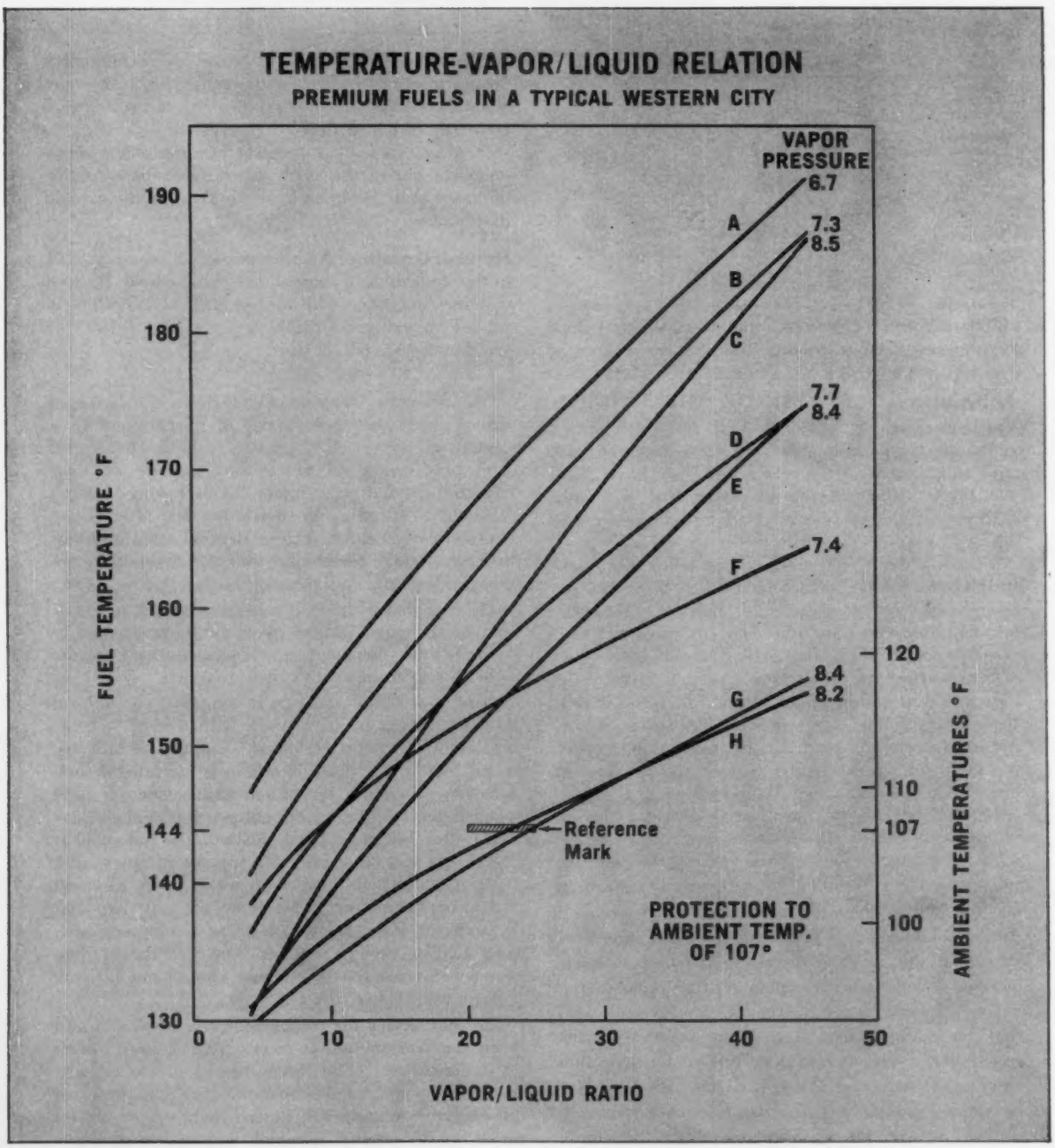
Now that the vindication is complete, the natural tendency might be to sit back with a loud "whew" and enjoy the fruits of victory. But the oil industry is still not in the position where it can afford such a luxury. It cannot be content with a few carefully worded press releases from company presidents saying justice has triumphed. Rather, the outcome at Tulsa sets the stage perfectly for the industry as a whole to climax its courtroom success with a skilled public relations effort. This is not the first time that Washington has tried to use oil as a whipping boy. And it likely isn't their finale. But their failure here was so abysmal that the public should not be permitted to forget it anytime soon.

To that advice for the oil industry, we would add a bit for Washington. It comes from Texaco's letter to stockholders: "The recent record of the Department of Justice suggests that the time has come for an objective reappraisal, at the highest government levels, of the manner in which this vital field of law enforcement is being administered."

Here's a practical method for analyzing Front-End Volatility

Ethyl Research uses temperature-vapor liquid ratio curves to study relative and absolute front-end characteristics of gasoline

by **GILBERT WAY**—*Research Representative*



The above curves were calculated by the CRC method using Ethyl Volatility Survey data.

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WHERE TO SET front-end volatility for optimum balance of economic and automotive benefits is an important question for refiners.

One result of Ethyl's work in this field is a routine approach to interpretation and comparison of seasonal volatility data. The method can be used to establish or review volatility requirements at both the refinery and marketing levels. Data from the Ethyl Volatility Survey are used as the basis for temperature-V/L studies. *Refiners may have analyses of their own marketing areas upon request!*

Method is Simple; Easy to Understand

Temperature-V/L ratio curves—widely accepted as a graphic representation of how gasoline vaporizes in a fuel system—are used to show the volumes of vapor formed per volume of liquid at any given gasoline temperature. (Curves were calculated by the CRC method.)

In addition to showing relative vaporizing tendencies among various fuels, the curves may be related to reference points that indicate average conditions of fuel temperature and limiting V/L in automotive fuel systems. In the accompanying graph, average conditions for premium fuels are shown by the reference mark ranging from 20 to 25 V/L at a fuel temperature of 144°F.

This reference mark range was established from the results of extensive road tests conducted in recent years. Many factors were considered in arriving at this practical bench mark, such as severity of test conditions, age and condition of fuel system components, and variation of individual cars from average characteristics.

In theory, a fuel having a curve which passes through the reference mark would represent highest desirable use of front-end "fill." Those above the mark would be more conservative and those below subject to vapor lock.

The estimate of fuel temperature was established by adding the temperature rise at the fuel pump under severe vapor locking conditions and the ambient temperature to which protection against vapor lock is desired. Experience has shown that this fuel temperature rise at the pump averages 37°F. In the marketing area represented in the graph, protection is desired up to 107°F.

Some Interesting Observations on Volatility

The figure shows a wide variation in vaporizing tendency of fuels. Fuels A, B and C indicate a conservative position. This is contrasted by high volatility and border line protection against vapor lock by curves of fuels G and H.

Curves having steep slopes are typical of fuels pressurized by butane. Those with flat slopes indicate a high pentane content. Fuels C, E and G have essentially the same Rvp of 8.4 to 8.5. They converge at a V/L of 4, the V/L of the Reid vapor pressure bomb.

A V/L of 25, however, is reached by fuel G at a fuel temperature of 144°F., whereas fuel C must reach 163°F. before evolving the same quantity of vapor. Thus fuel C offers more protection against vapor lock than fuel G when abnormally high temperatures are encountered. This illustrates that, *for a given Rvp, butanized* fuels offer greater vapor lock protection in motor vehicles than fuels that are pressurized largely by pentane. Another way of comparing these two fuels is at constant temperature: at 150°F., fuel G has 35 V/L, fuel C only 16.

How Ethyl Research can help you

In addition to participating in Oil Industry cooperative studies, Ethyl Research has worked with many individual oil companies in studies of vapor locking tendencies of fuels and engines.

The experience gained in these programs provides a broad understanding of the problems associated with front-end volatility.

Our engineers are prepared to bring you analyses of Temperature-V/L characteristics of fuels from marketing areas of your choice, based on Ethyl Volatility Survey data. For overseas areas where Survey data are not available, studies can be made for refiners who supply sample inspection information.

If you would like this service, or more information about it, just contact your Ethyl Representative. He'll be glad to make arrangements.

ETHYL ANTI-KNOCK COMPOUND — ETHYL CORPORATION

ETHYL CORPORATION
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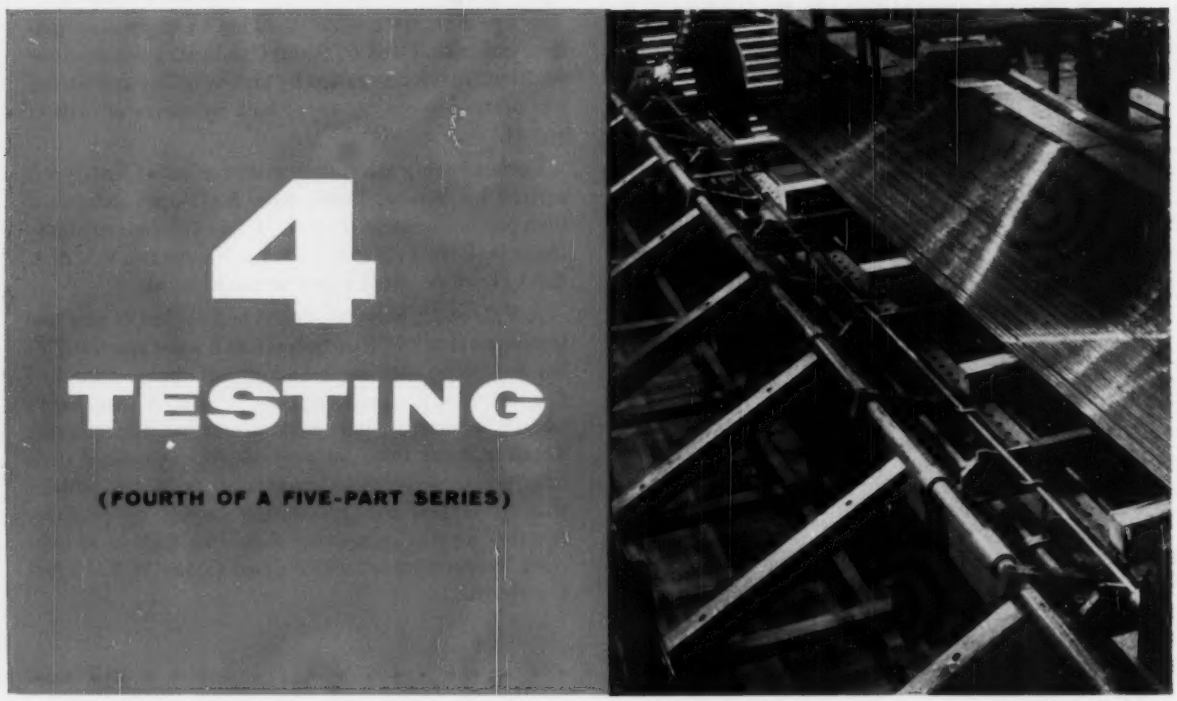
How lasting quality is Heat Exchanger



The quality of Phelps Dodge heat exchanger and condenser tubes is continually controlled at every stage of the entire fabricating operation by a special "in-mill" laboratory. In addition, the finished tubes are given exhaustive physical, chemical and metallurgical tests to assure quality and conformance with specifications.

All physical tests, including hydrostatic, flattening and expansion tests, are performed in strict accordance with ASTM and customer specifications. In the chemical laboratory, samples of the tubes are analyzed both chemically and spectrographically to determine the exact composition and conformance to the specifications. Experienced metallurgists minutely examine the grain structure of the metal in samples of both "in-process" and finished tubes. The grain size and temper are also carefully determined.

Throughout the entire tube fabricating operation—from raw materials to finished product– quality is the keynote. That's why Phelps Dodge tubes are preferred by those who demand the finest . . . the manufacturers and users of heat exchangers and condensers.

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built into Phelps Dodge and Condenser Tubes...

Finished tubes receive the hydrostatic test, a quality control check in which water is pumped into the tubes at high pressures.

Another quality control test is this multi-frequency eddy current device which helps assure flawless tubes.

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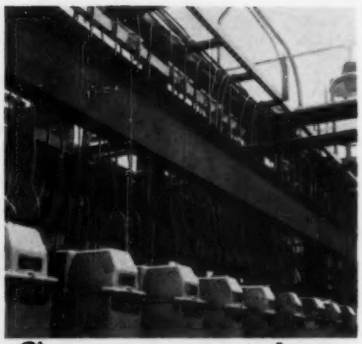
Oil companies throughout the country specify Safety MI Cable for hazardous applications and for remote control and instrumentation. Outstanding design engineers recommend it. One four-part reason...MI's exceptional record of safety, efficiency, permanence and economy. ■ Investigate the many unique characteristics of this versatile cable construction by writing for the new MI catalog



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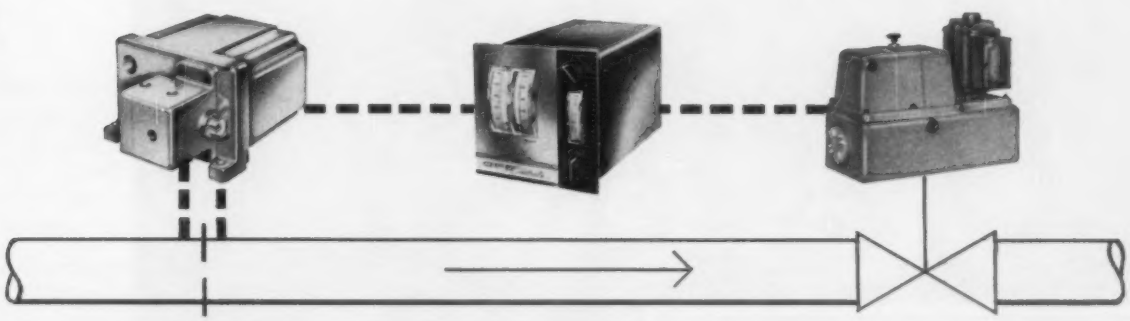
MI FOR HAZARDOUS AREAS

Electronic Flow Control System built by **GPE Controls** brings you the highest possible degree of dynamic accuracy. Three times as fast as other systems. Outstandingly reliable. Adaptable to nearly all flow control jobs. Ready for you now at surprisingly **low cost.** Easy, inexpensive installation: Simple unshielded wiring, no air compressors, no separate hydraulic pumps, no tubing connections. Low maintenance; unequalled performance.



776F Flow Transmitter

Lowest differential pressure requirement of any transmitter – as low as 3″ w.c. for maximum output of 25 volts d.c. at power levels up to 5 watts. Permits use of larger orifices; transmission over greater distances with simple unshielded wiring; simultaneous operation of controllers, recorders, etc. Automatic square root extraction for straight summarization of flows, highest accuracy at large turndowns. Fully transistorized . . . no vacuum tubes.

R462 Flow Indicating Controller

Complete linear indication of both set point and process – not just an error indication. Set point and process scales are parallel, for fast visual comparison. Manual/automatic control. Valve position indicator is optional. Outstandingly simple in design and construction. No vacuum tubes, no transistors. Compact panel-mounting, easy installation.

687 Electro-Hydraulic Valve Actuator

The simplest, lowest-cost way to operate a control valve from an electric signal. This model positions 4″ double-seated valve at 1000 p.s.i. pressure drop. Completely self-contained. Feedback through process for true integral control . . . proved most reliable in more than 10,000 installations with up to 30 years operating experience. Automatic locking with power failure simplifies start-up of process.

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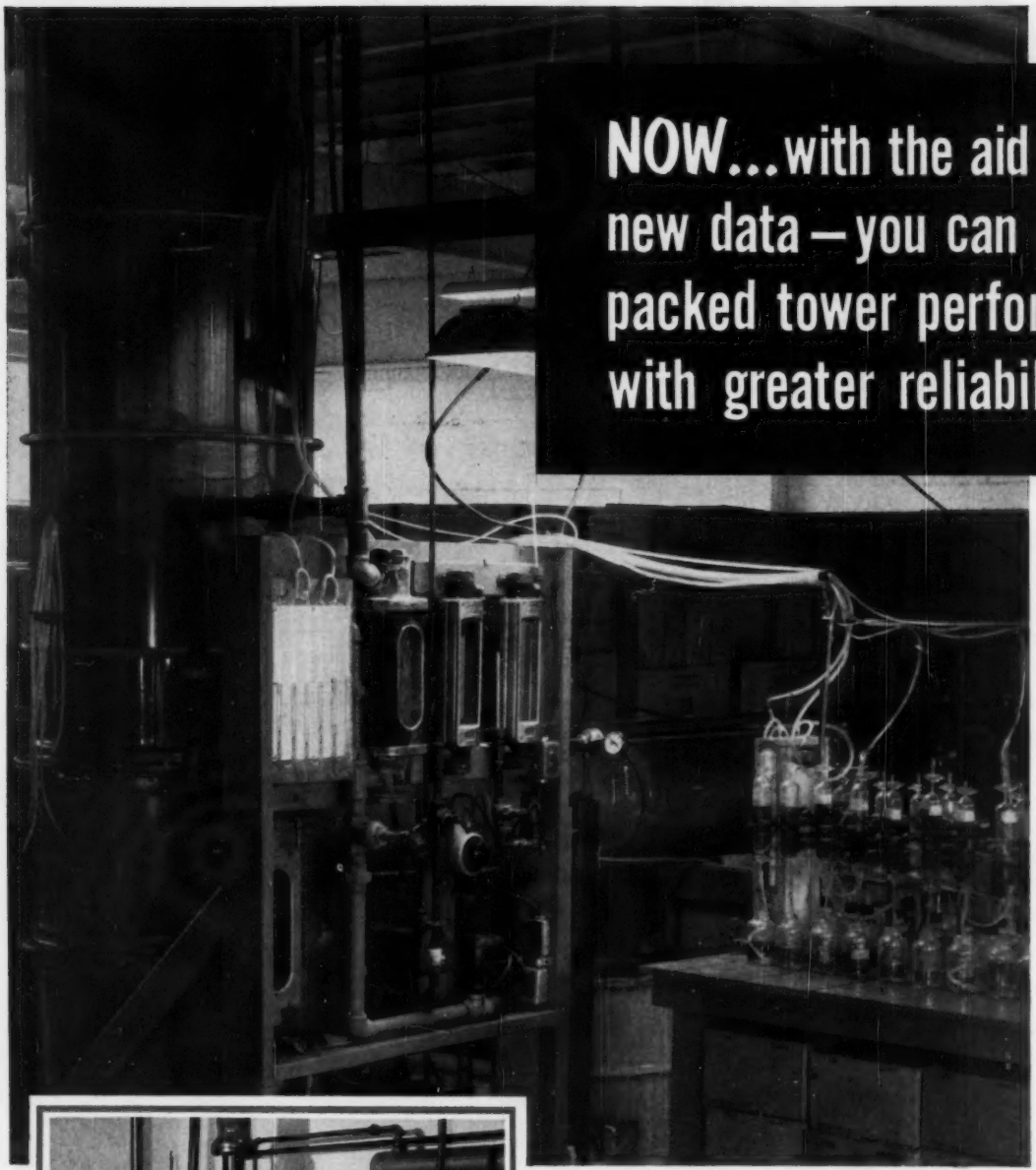
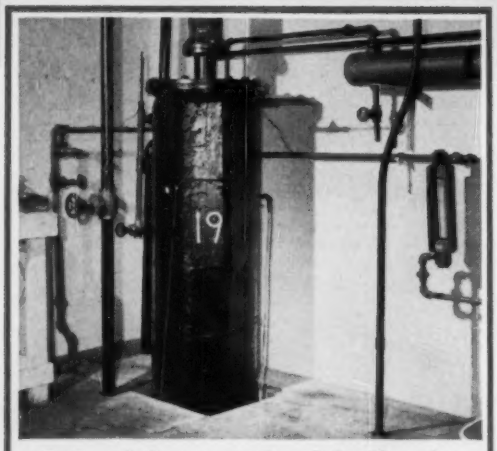
NOW...with the aid of this new data—you can predict packed tower performance with greater reliability



One of the 30" diameter experimental towers used to accumulate gas mass transfer coefficients and pressure drop data on tower packings of various types and sizes.



A view of the upper section of the fifteen foot high, 24" diameter distillation tower in U. S. Stoneware's Engineering Laboratories.

159-G

Up to a few years ago, data on packed columns sufficiently reliable to enable design engineers to predict performance in specific applications was virtually non-existent. Each new packed column installation had to be designed afresh, and was usually over designed to provide an adequate margin of safety. Data reflecting the experiences of plants operating towers of industrial size was generally not available; published data reflecting the work of universities conducted in small experimental towers, (because of limited availability of funds) while helpful, left much to be desired when used for scale-up.

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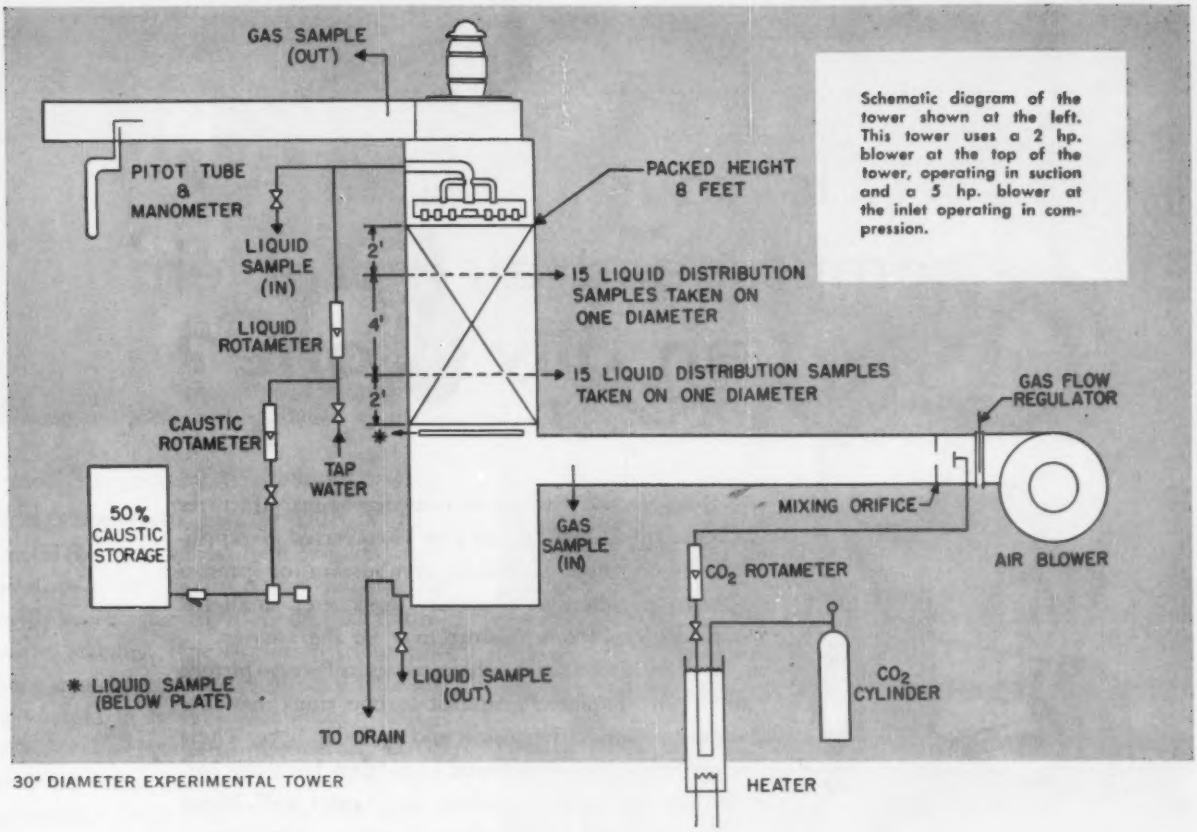

Schematic diagram of the tower shown at the left. This tower uses a 2 hp. blower at the top of the tower, operating in suction and a 5 hp. blower at the inlet operating in compression.

30" DIAMETER EXPERIMENTAL TOWER

The development of high capacity tower packings such as the Intalox Saddle® and the Pall Ring brought with it the need for data that could be used to predict with reasonable accuracy the performance of large size towers.

Accordingly, The U. S. Stoneware Co., began building some four years ago a series of experimental towers of such size that data obtained from their use could be accurately translated in specific terms and could be used to predict the performance of large towers with reasonable accuracy.

In these past four years we have conducted hundreds of tests involving various types of tower packings, distributors, packing support methods, in absorption, fractionation, stripping and distillation. Test runs have been repeated over and over again to be sure that the data obtained would reliably indicate what could be reasonably expected.

Data obtained from these tests have been used by our engineers in designing towers up to many feet in diameter and performance of the completed tower has almost invariably equalled or exceeded anticipated performance.

This data is now being released for general distribution to chemical engineers everywhere without cost or obligation. The first release covers more than fifty graphs showing performance of various packings with data reflecting capacity and efficiency, etc. If you would like to receive a set and be placed on our mailing list for future releases as they occur please write us on your company letterhead. They will be sent to you promptly.

PROCESS EQUIPMENT DIVISION

U. S. STONEWARE
AKRON 9, OHIO

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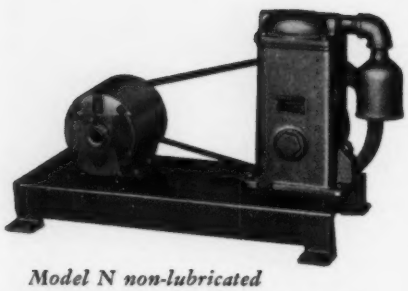
is your compressed air problem an oily one?

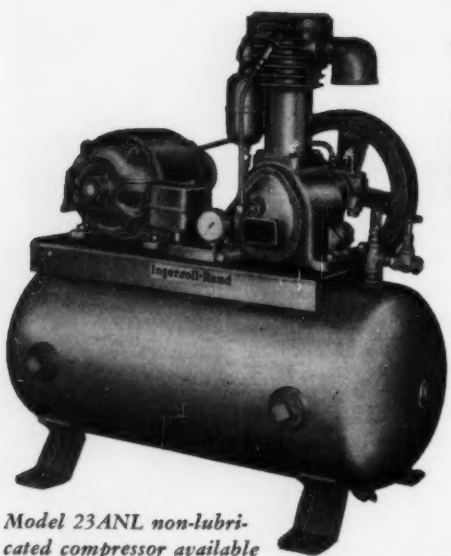
If so, see the leading air compressor manufacturer —Ingersoll-Rand. For *oil free compressed air* applications in food, chemical, combustion or process control, packaging, laboratory work, etc., small I-R non-lubricated compressors may be the answer.

Ingersoll-Rand non-lubricated units feature pistons fitted with patented graphitic-carbon rings that prevent contact of the piston and cylinder bore. These segmented rings with metal expanders have the correct bearing pressure against the cylinder wall. Metal to metal contact is eliminated and no lubricant is required in the compressor cylinder. The crank case is lubricated but oil cannot pass the crosshead portion that is equipped with seals and oil control or scraper rings.

Why not have an experienced Ingersoll-Rand air engineer or distributor help you solve your problems.



Model N non-lubricated compressor available in ½, ¾ and 1 hp sizes.



Model 23ANL non-lubricated compressor available in ¾, 1 and 1½ hp sizes.

Ingersoll-Rand

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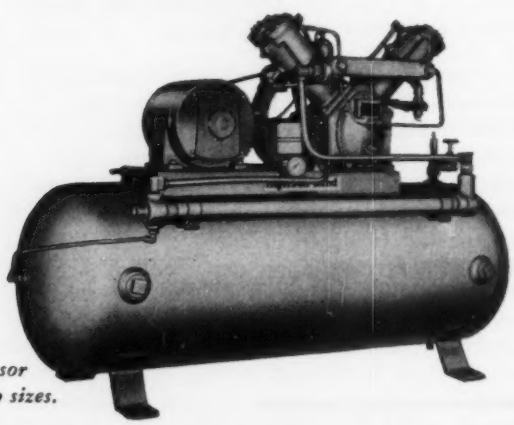
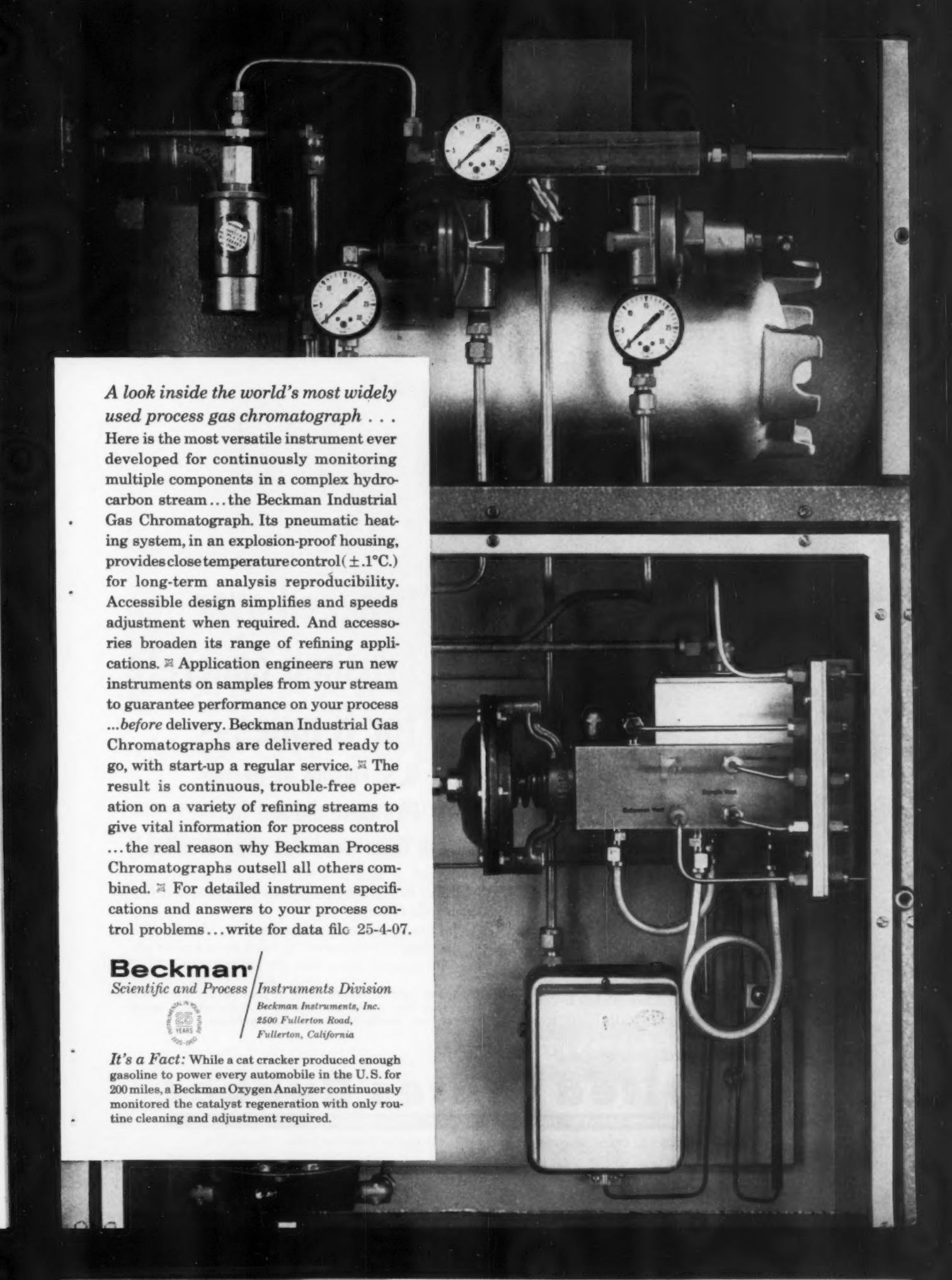


Model 235HNL non-lubricated compressor available in 2 and 3 hp sizes.

Larger I-R Reciprocating Compressors are available in non-lubricated design.



A look inside the world's most widely used process gas chromatograph . . .

Here is the most versatile instrument ever developed for continuously monitoring multiple components in a complex hydrocarbon stream . . . the Beckman Industrial Gas Chromatograph. Its pneumatic heating system, in an explosion-proof housing, provides close temperature control (±.1°C.) for long-term analysis reproducibility. Accessible design simplifies and speeds adjustment when required. And accessories broaden its range of refining applications. ⌘ Application engineers run new instruments on samples from your stream to guarantee performance on your process ...*before* delivery. Beckman Industrial Gas Chromatographs are delivered ready to go, with start-up a regular service. ⌘ The result is continuous, trouble-free operation on a variety of refining streams to give vital information for process control ... the real reason why Beckman Process Chromatographs outsell all others combined. ⌘ For detailed instrument specifications and answers to your process control problems . . . write for data file 25-4-07.

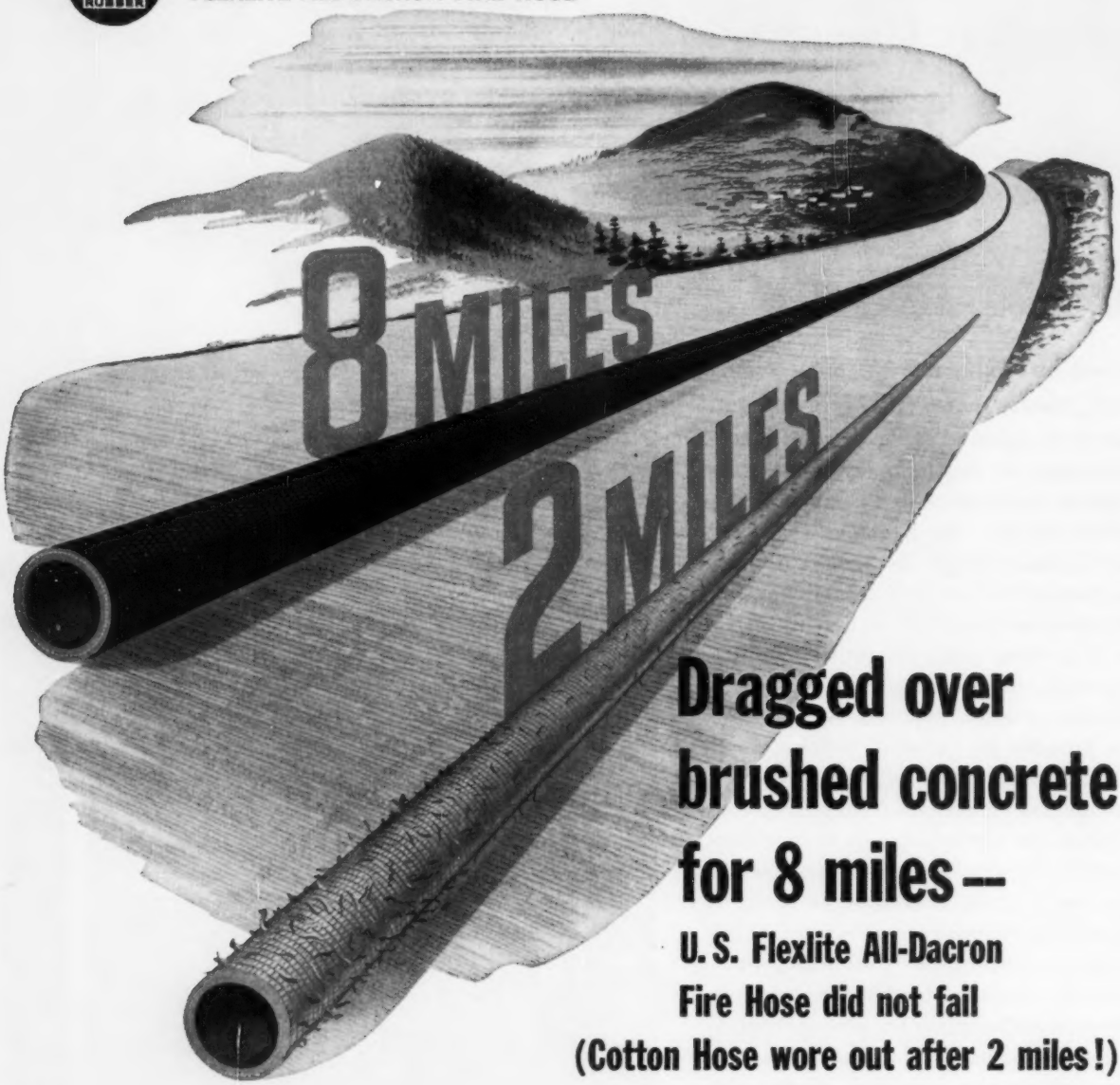
Beckman®

Scientific and Process Instruments Division

Beckman Instruments, Inc.
2500 Fullerton Road,
Fullerton, California

It's a Fact: While a cat cracker produced enough gasoline to power every automobile in the U.S. for 200 miles, a Beckman Oxygen Analyzer continuously monitored the catalyst regeneration with only routine cleaning and adjustment required.

FLEXLITE ALL-DACRON FIRE HOSE



Dragged over brushed concrete for 8 miles—

U.S. Flexlite All-Dacron Fire Hose did not fail

(Cotton Hose wore out after 2 miles!)

This test convincingly proves the overwhelming ruggedness of Flexlite® Hose. It demonstrates, too, that a hose can be rugged and at the same time light and *flexible*. Flexlite's lightness enables fire crews to fight fire without being hampered by excess weight.

U.S. Flexlite Hose brings you these other advantages: It won't absorb water and hence can't freeze. It is highly resistant to oils and chemicals. Every foot is subjected to five hundred pounds test pressure before leaving the factory.

This hose comes in any color for ready identification as a fire hose. This prevents its being carried off or utilized for purposes other than fire fighting.

• • •

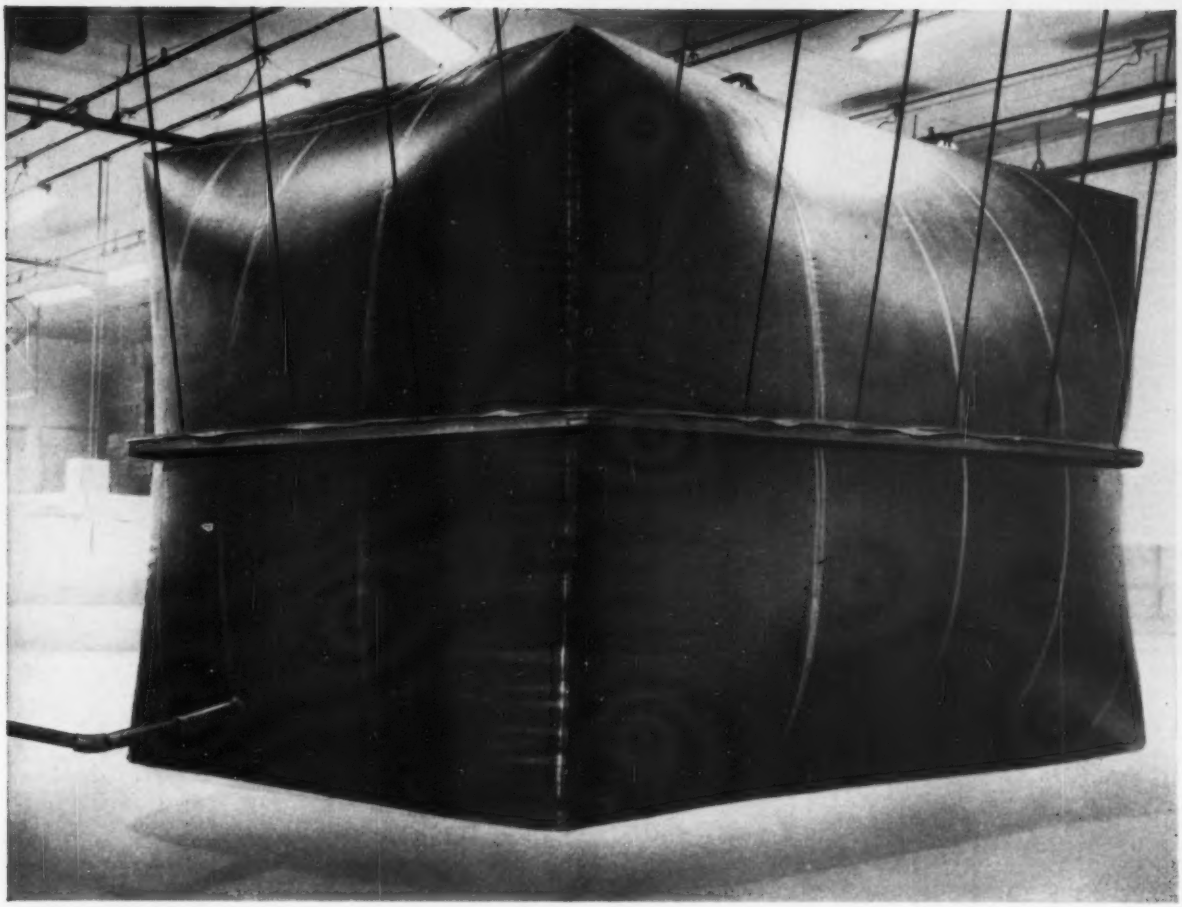
When you think of rubber, think of your "U.S." Distributor. He's your best on-the-spot source of technical aid, quick delivery and quality industrial rubber products.

Mechanical Goods Division

United States Rubber

WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.



STOP COSTLY VAPOR LOSS

with a Reeves Vulcan BREATHER BALLOON

. . . makes your storage tank a closed system

. . . can pay for itself in just 6 months!

Now save on vanishing vapors during gasoline and gas storage or transfer, or when your regular gas tank is shut down . . . with Reeves Vulcan Breather Balloons, the most efficient, low-cost system of vapor conservation ever developed. They require no skilled labor to install, no high-priced housing . . . cost practically nothing to maintain. Every Breather Balloon ever sold, here and abroad, is still in use . . . still returning profits. Not a single failure in over 12 years! For full details, write:

Reeves Brothers, Inc., Vulcan Rubber Products Division
1071 Avenue of the Americas, New York 18, New York

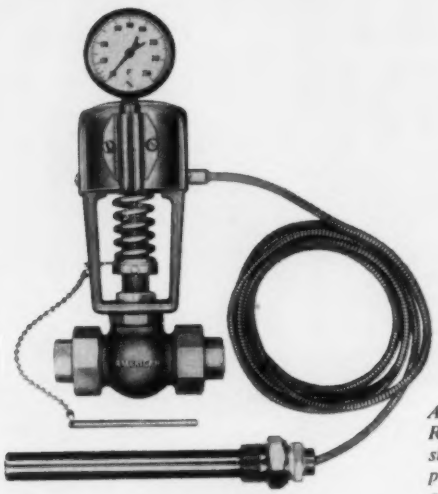
Another

REEVES VULCAN
RUBBER PRODUCT

For more data on advertised products, use Readers' Service Cards, last page.

immediate

AMERICAN TEMPERATURE REGULATORS begin corrective action with less than 1/10 degree change at the bulb



American Temperature Regulators are made in sizes ½" to 4". Temperature ranges as low as minus 15° F. to 50° F.—as high as 240° F. to 350° F.

response

You get fastest possible temperature response from these new regulators because the stem cannot bind and retard valve action.

The valve stem on American Temperature Regulators is sealed off by a friction-free bellows that makes practical a nonleaking packless valve. Also contributing to fast, stable action is the use of an extra-long preflexed adjusting spring. This spring permits a long range of temperature adjustment without disturbing valve sensitivity at normal levels.

There are other high-quality features in American Temperature Regulators: maximum use of stainless steel; standardized parts; the fewest possible components; and unitized assembly. In addition, compactness simplifies installation in "tight" locations.

Accurate temperature regulation and attention-free operation mean long-term economy. Your industrial supply distributor will gladly help you select the right American Temperature Regulators for your needs. Write for Bulletin 114A.

MANNING MAXWELL & MOORE INC. M&M TRADE MARK

AMERICAN TEMPERATURE REGULATORS

A product of

MANNING, MAXWELL & MOORE, INC.

Gauge and Instrument Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

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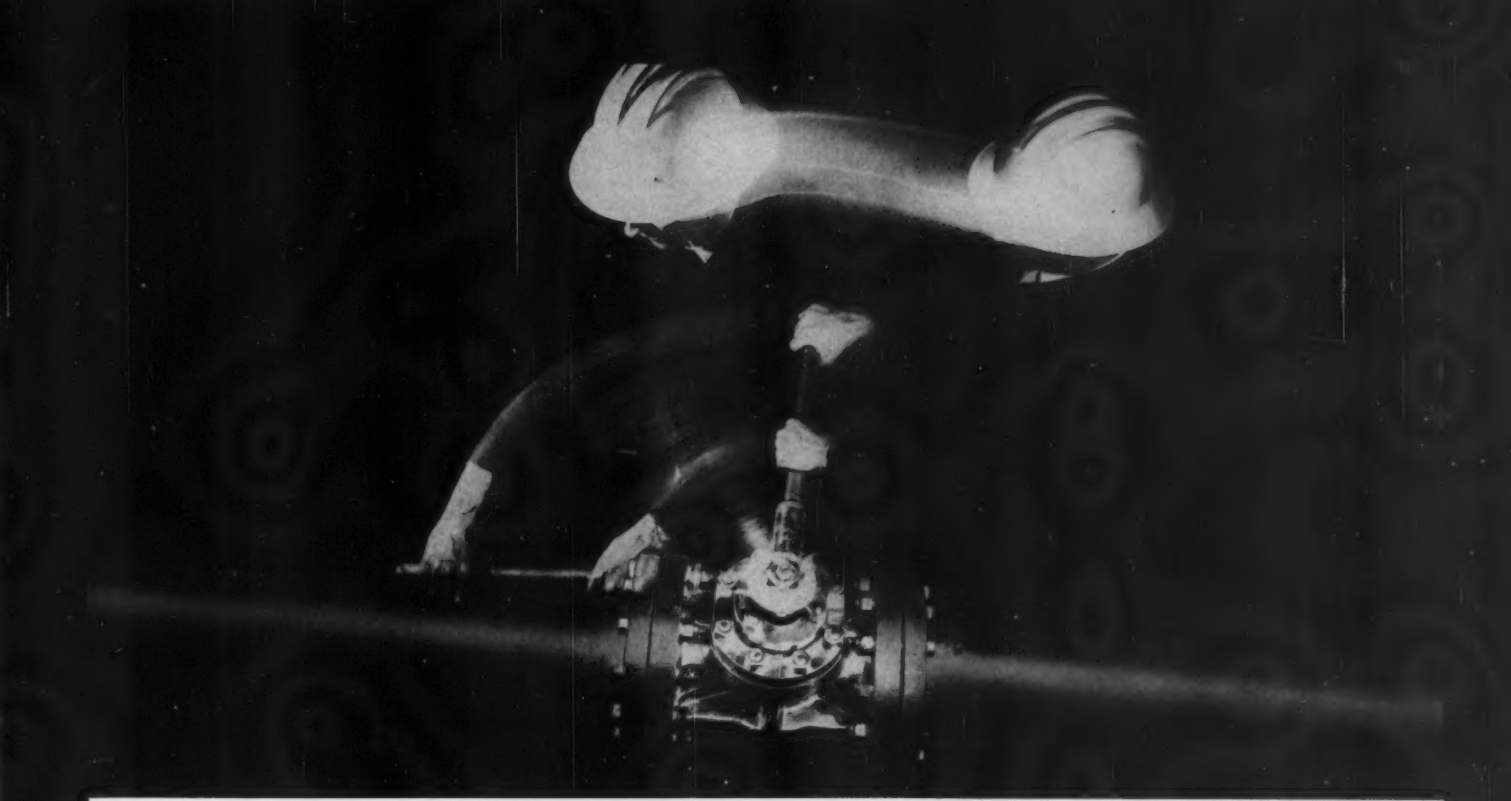


Stroboscopic photo shows fast, smooth quarter turn closure of Rockwell-Nordstrom lubricated plug valves.

THESE LUBRICATED VALVES CLOSE 2 TO 5 TIMES FASTER

Rockwell-Nordstrom *lubricated* plug valves save time, reduce flow control errors because they close quickly, positively and easily with just a quarter turn. One man can open or close a dozen of these valves in the time it takes to laboriously wrestle one hand wheel on other types of valves.

Faster closure isn't the only advantage of Rockwell-Nordstrom lubricated plug valves. Their Sealdport pressurized lubrication system insures positive shut-off by creating powerful seals of hydraulically energized lubricant at the seat ports. And, isn't it just common sense that any lubricated mechanism will work better, longer and at far lower cost than a "dry" one? Get complete details on Rockwell-Nordstrom lubricated plug valves (the world's most complete line) by writing: *Rockwell Manufacturing Company, Pittsburgh 8, Pa.; Canadian Valve Licensee, Peacock Brothers Limited; Rockwell International S.A., Geneva, Switzerland.*

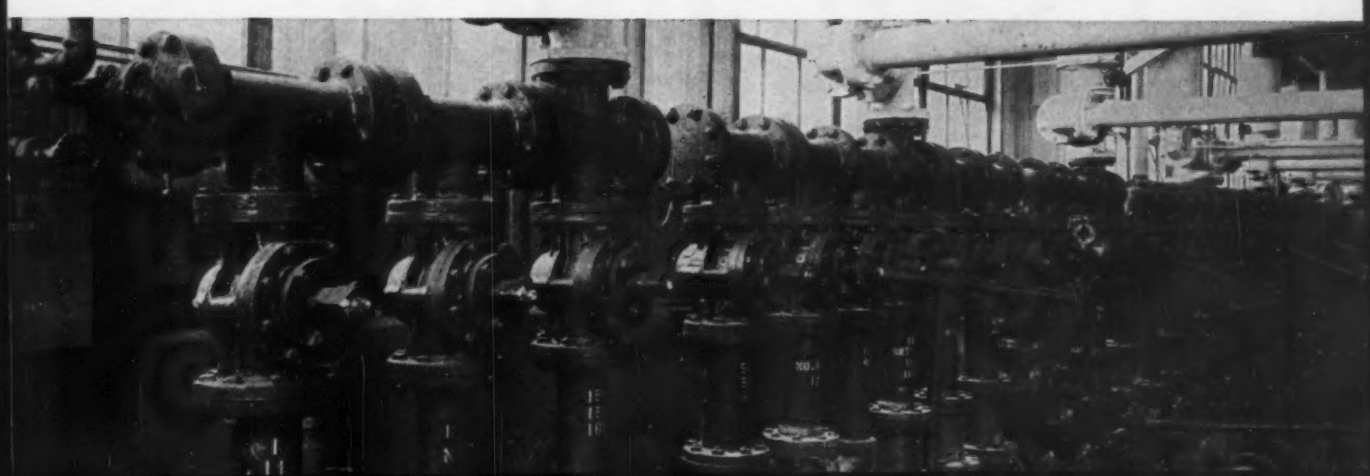
Lubrication Makes The Difference

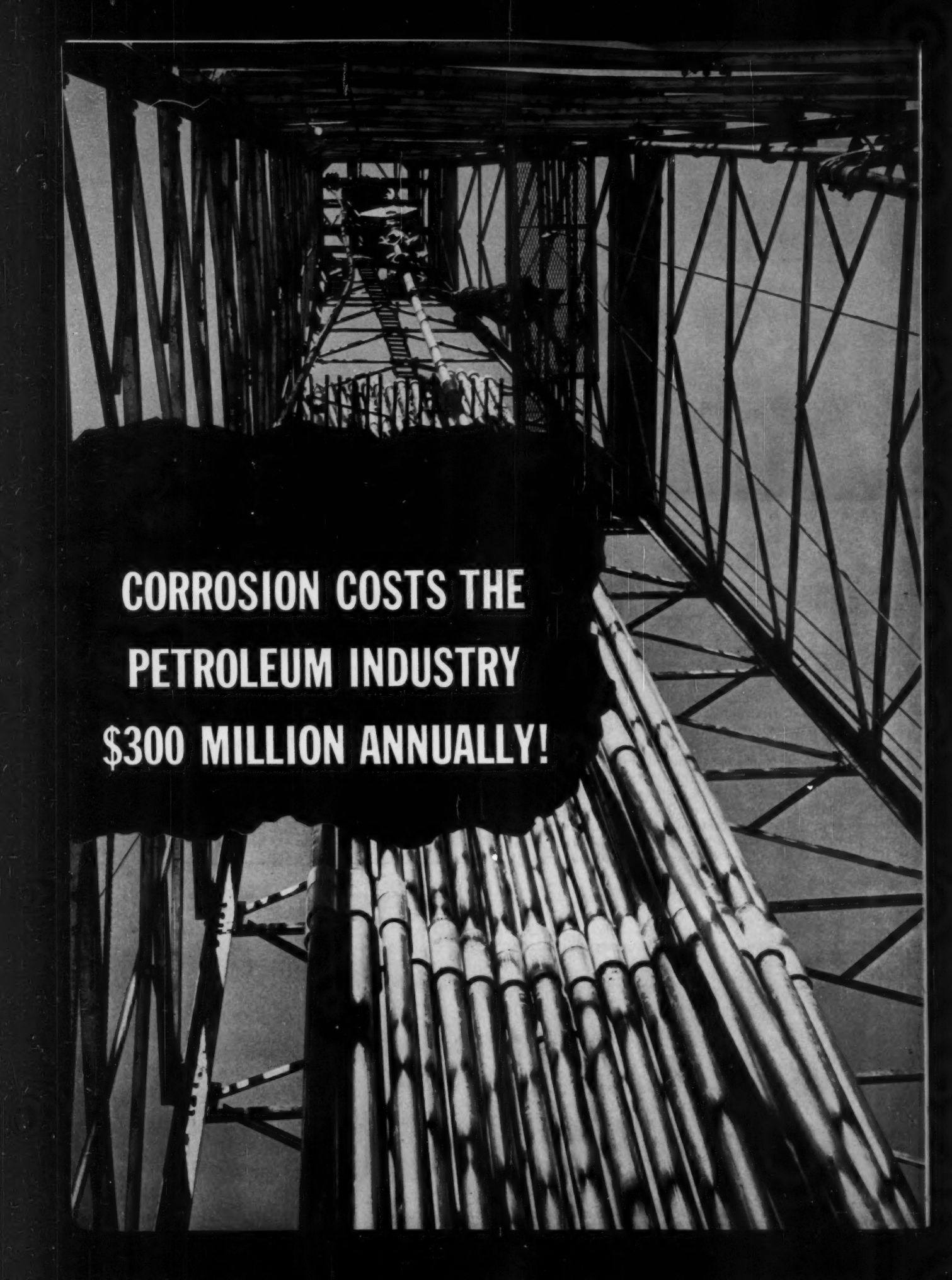
ROCKWELL-Nordstrom VALVES

another fine product by

ROCKWELL

One man can open or close this refinery transfer manifold 3 times faster than three men winding handwheels on ordinary valves.




CORROSION COSTS THE
PETROLEUM INDUSTRY
$300 MILLION ANNUALLY!

...Now You Can Control 96% of All Your Petroleum Corrosion Problems with this Proven PITT CHEM® Coating System!

Corrosion ranks as a major "cost" factor in the production of crude oil and petroleum products. The American Petroleum Institute estimates that corrosion costs the industry 300 million dollars annually, or 11 to 14 cents per barrel of throughput.

From initial exploration, through transportation and storage, Pittsburgh now provides the petroleum industry with a complete system of heavy duty protective coatings formulated to meet specific petroleum corrosion conditions. Service-proven PITT CHEM Coatings save thousands of dollars every day, protecting valuable equipment against sour crudes, condensate, sweet oils and a variety of corrosive environmental conditions.

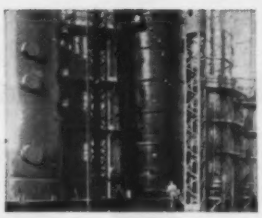
PITT CHEM Tarset, Tarmastic and Insul-Mastic are tough, *heavy film* coatings that outlast conventional maintenance paints 10 to 20 times. You measure their protection in *decades*, not years. They can be cold-applied by brush, spray gun or roller. No other family of protective coatings can solve so *many* of your corrosion problems so *economically*.

For more information, mail the coupon below. Then consult your nearest PITT CHEM Distributor—he's listed in the "Yellow Pages." Or call Pittsburgh Coke & Chemical Company in Pittsburgh, New York, Chicago, Houston or Los Angeles. A PITT CHEM Corrosion Engineer will be glad to discuss your corrosion problems without obligation.

PITT CHEM TARSET®

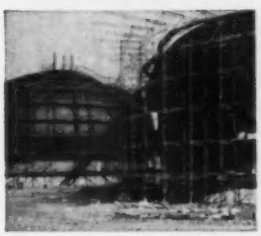
Tarset, the original, patented, coal tar-epoxy coating, has solved some of the most difficult corrosion problems in the petroleum industry. Applications to crude oil storage tank interiors, gasoline and jet fuel storage tanks, underground pipelines and pipe joints have proven Tarset's protective ability.

PITT CHEM TARMASTIC®



PITT CHEM Tarmastic coal tar coatings are a series of protective coatings designed to meet a wide variety of corrosive conditions at moderate cost. Oil tank exteriors, structural steel, concrete, piling and waste systems are just a few of the many proven applications for Tarmastic coatings.

PITT CHEM INSUL-MASTIC®



Vapor and moisture penetration problems are solved economically and effectively with Insul-Mastic Gilsonite-asphalt coatings. Petroleum plants use Insul-Mastic to protect metal buildings, tanks and equipment. Insul-Mastic insulating mastics provide good heat loss reduction and condensation control.

PITT CHEM PIPELINE ENAMELS

For the long-term preservation of underground pipelines, coal tar enamels are considered the most practical and effective method of protection ever developed. PITT CHEM Pipeline Enamels are widely recognized for their excellent quality and service record on oil, gas and water transmission and distribution lines throughout the nation.

Send for Your Free Copy of this PETROLEUM CORROSION DATA FILE

Includes a survey of corrosion problems in the Petroleum Industry, data on PITT CHEM Coating Systems and a coating selector guide.

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Company_____

Street_____

City_____ State_____

PROTECTIVE COATINGS DIVISION

PITTSBURGH COKE & CHEMICAL CO.

Grant Building • Pittsburgh 19, Pa.

978

K&M ZEBRA

THE YEARS-AHEAD DEVELOPMENT IN PIPE INSULATION!

3 times faster to apply than 2-layer sectional insulation, new "K&M" ZEBRA is a low, medium and high-temperature multi-layer sectional-type thermal insulation. It's as rugged as it is speedy. Its deflection at breaking point is 2 to 4 times that of ordinary insulation. That's why breakage during installation practically disappears. There's a new ease of handling, too. No skin irritation. No skin penetration by ragged projections. "K&M" ZEBRA is smooth-surfaced. And, too, it's easy to cut and fabricate . . . practically dust free. Get more information on this exciting, new development in pipe insulation. Write to us today for more information. Dept. I-240.

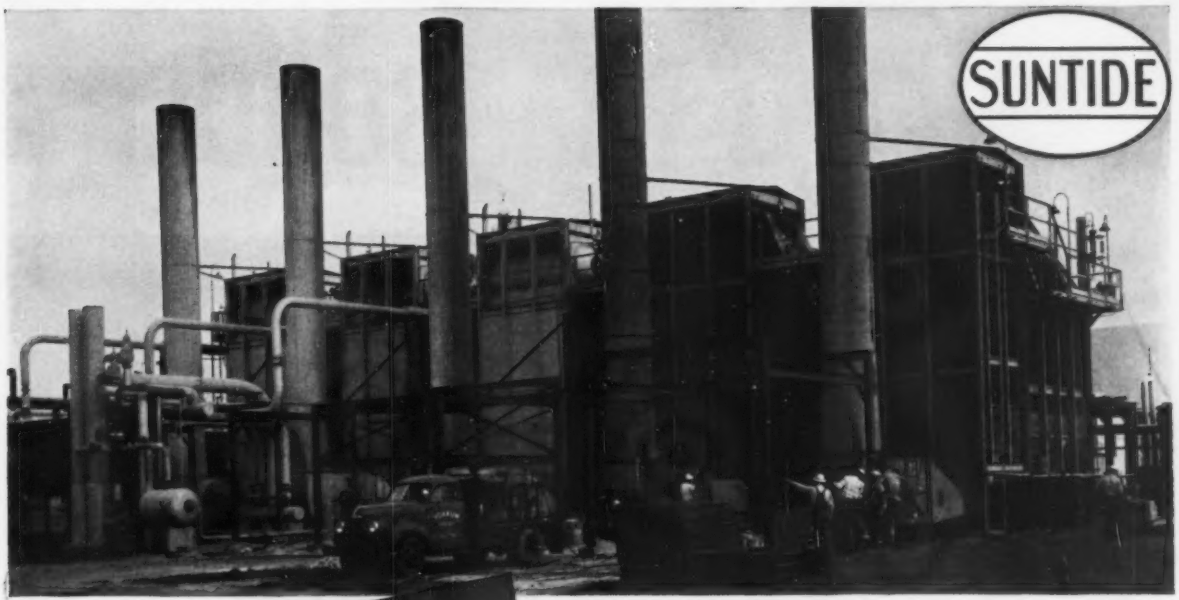
• For temperatures of 200°F. to 1200°F. • Withstands shock and heat without warping or cracking. • Made of calcium silicate—asbestos fiber bonded felts. • Can be re-used . . . can be dismantled and re-applied. • Available in wide range of sizes and thicknesses. • Tested by an independent testing laboratory.

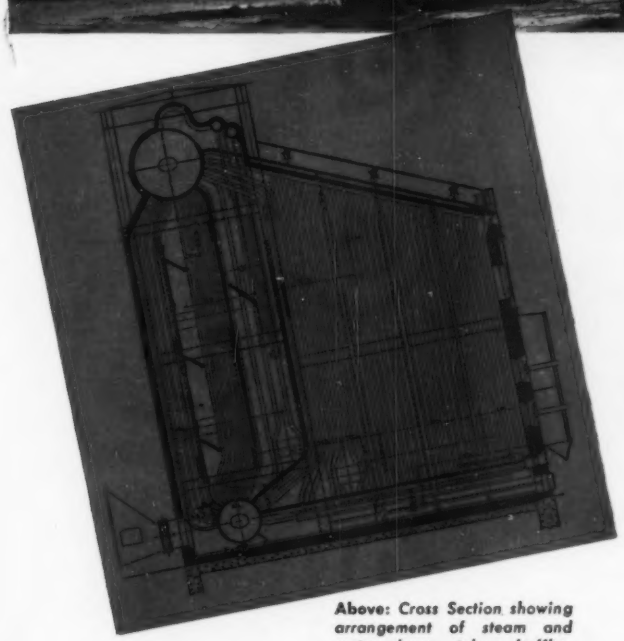
K·M
REST IN ASBESTOS

KEASBEY & MATTISON
COMPANY • AMBLER • PENNSYLVANIA

Vogt STEAM GENERATORS

at SUNTIDE REFINING COMPANY
Viola, Texas





Above: Cross Section showing arrangement of steam and water drums, tubes, baffles, and furnace.

5 EFFICIENT AND ECONOMICAL UNITS SERVE THIS MODERN REFINERY

Principle Data Each Unit

- 85,000 pounds steam per hour capacity, designed for 500 lbs. S.W.P. and 625° F. total temperature.
- Water cooled furnace.
- Burners for Gas and Oil fuel.

Vogt offers a complete line of custom built and package type steam generators. Available in bent tube and straight tube designs for solid, liquid, or gaseous fuels burned singly or in combination.

Write for bulletins. Dept. 24A-BPR

OTHER VOGT PRODUCTS

Forged Steel Valves, Fittings and Flanges—
Petroleum Refinery and Chemical Plant Equipment
Heat Exchangers
Ice Making and Refrigerating Equipment

HENRY VOGT MACHINE CO.

Box 1918, Louisville 1, Kentucky

SALES OFFICES: New York, Chicago, Cleveland, Dallas, Camden, N. J. St. Louis, Charleston, W. Va., Cincinnati, Los Angeles.

For more data on advertised products, use Readers' Service Cards, last page.

HIGH-PRECISION SERVO TRANSDUCER

NEW FROM BRISTOL

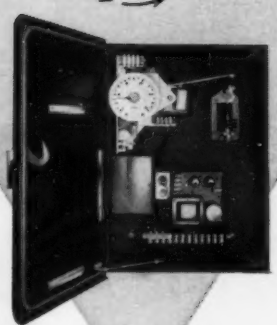
CONVERTS MEASUREMENTS LIKE THESE:

Pressure
Absolute pressure or vacuum
Differential pressure
Liquid level
Flow
Temperature
Linear motion
. . . and many others

INTO

SHAFT POSITION FOR OPERATING:

Transmitting slidewires
Synchro Resolvers
Alarm switches
Analog-to-digital encoders
Upset contacts
Limit switches
Deviation contacts
. . . etc., etc., etc.



New Bristol Dyna-Servo Transducer uses same convenient panel-type packaging as regular instruments, adds new flexibility to instrument system design.

A precision feedback package . . . easy to use as a regular instrument

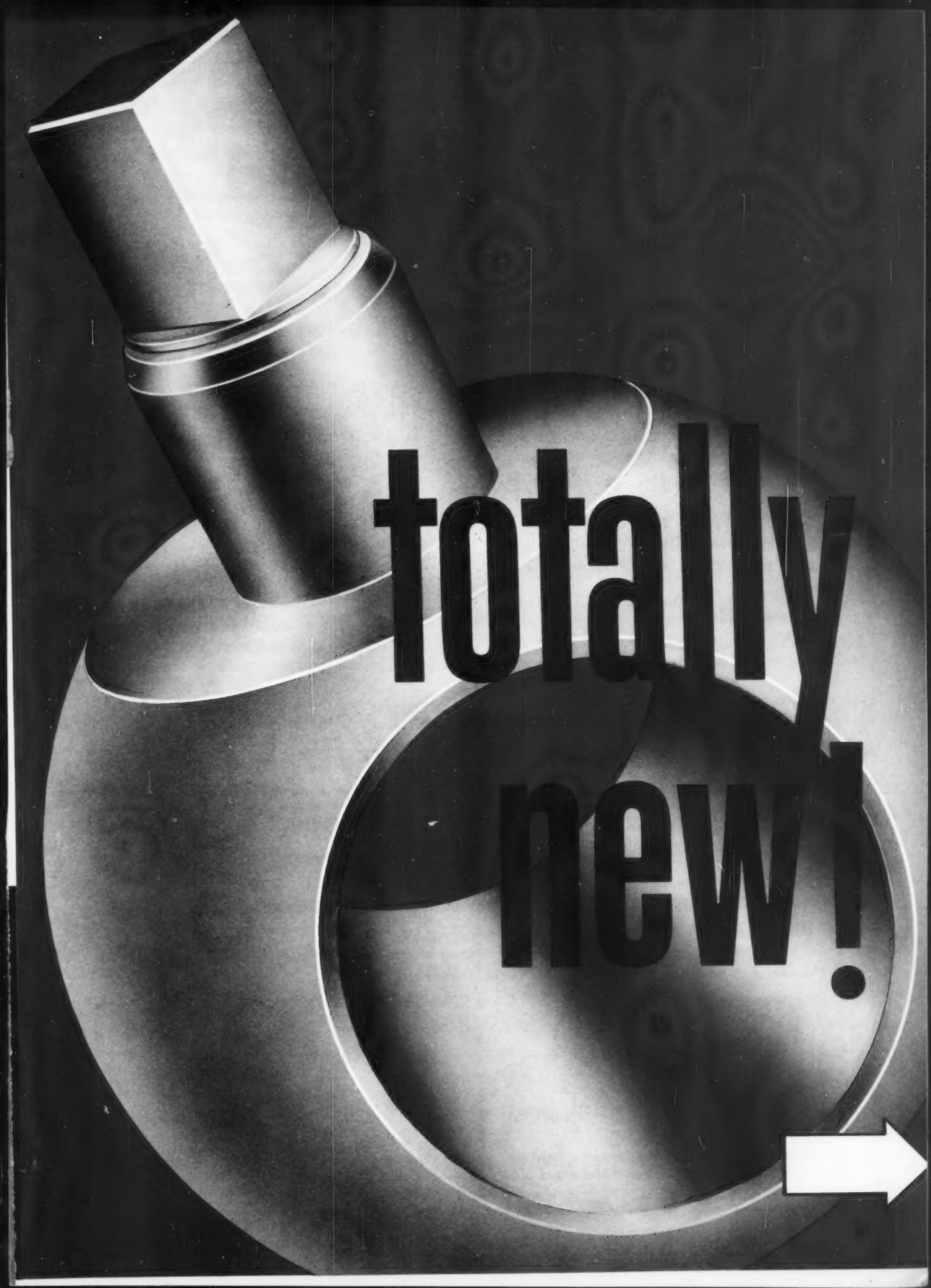
It's the new Bristol Dyna-Servo Transducer, a high-torque, electronic servo unit that converts position or measurements into precision shaft angle . . . uses same highly accurate, service-proved electronic system as famous Bristol Dynamaster* potentiometer and bridge instruments . . . works with high-precision Bristol measuring elements, long known for accuracy, sensitivity, stability. Write for complete technical data on this new Bristol contribution to instrumentation flexibility. The Bristol Company, 111 Bristol Road, Waterbury 20, Conn.

*T. M. Reg. U. S. Pat. Off. 9.27

BRISTOL . . . for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more data on advertised products, use Readers' Service Cards, last page.


totally
new!

Only *FLO·BALL* valves are bearing-fixed for maintenance-free long life!

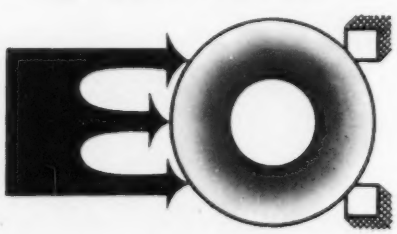
. . . with all the features you must have:

- **Top loading**
- **Replaceable seats**
- **One-piece ball and stem**
- **90° on-off**
- **Two-way flow**

Series 711, 150 lb. ASA Flanged, Reduced Port

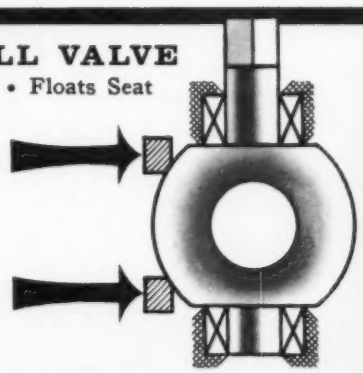
Now available . . . the result of years of intensive service in the missile-space industry . . . proven in thousands of adverse applications . . . now at mass produced prices . . . the most advanced line of ball valves ever manufactured . . . for you!

ORDINARY BALL VALVE
Floats Ball • Fixes Seat



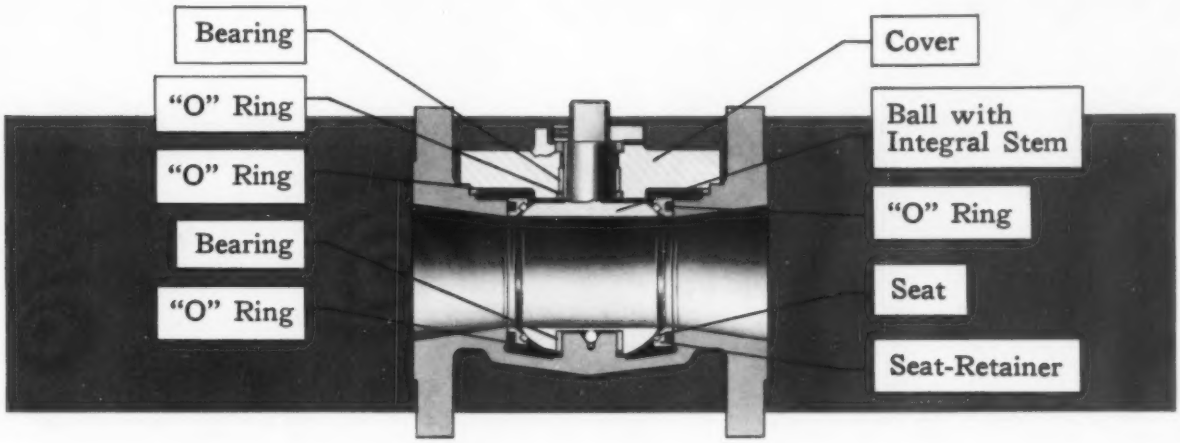
Floating ball puts excessive pressure load on fixed seats. Results in distortion and short life.

FLO • BALL VALVE
Fixes Ball • Floats Seat



FLO·BALL **bearings absorb all pressure forces. Elimination of excessive seat loading insures long life.**

The Series 711 ***FLO·BALL*** valves are available for off-the-shelf delivery. Manufactured to standard ASA dimensions in carbon steel, 316 stainless steel, and aluminum for body and ball, Teflon for seats, and Buna "N" O-Ring seals. Other materials are also available. These valves operate at pressures to 300 psi, temperatures to 400° F.



The Hydromatics Series 711 FLO•BALL valve gives you the features you must have!

- Bearing-Fixed ball. Engineered to withstand shock and impact without distortion or backlash.
- Top loading. Valve can be disassembled and assembled without removing it from line. No special tools are required.
- Self adjusting, replaceable seats. Both balanced seats are self-aligning and self-adjusting for controlled seat loading and positive seal.
- No lubrication. Operates completely without lubrication.
- Zero leakage. At all operating pressures, including vacuum to 10^{-6} mm. of Hg.
- One-piece stem and ball. Simplified construction adds strength, precision and lower torque.
- Maximum flow efficiency. The open ***FLO·BALL*** valve provides an unrestricted, straight-thru fluid path.
- Lowest torque. Bearing-Fixed construction results in effortless, fast-action with low torque.
- Two-way flow. Exclusive ***FLO·BALL*** seat design principle insures perfect seal in both directions.

Hydromatics, Inc.

Mail this postage-free card today

Tear Along This Edge

Gentlemen:
Your Bearing Fixed Flo·Ball valves from ⅛" to 24" may help solve a problem relating to the control of:

☐ Corrosive Liquids ☐ Cryogenic Liquids ☐ Throttling Flow
☐ Vacuum ☐ High Pressure

My flow problem is_____

I now use Ball Valves in these sizes_____

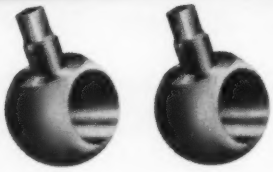
PLEASE: ☐ Have salesman call ☐ Send technical data

My name_____ Position_____

Company name_____

Address_____

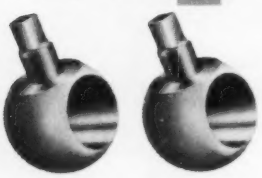
City_____ State_____

Bearing fixed 

New Zero leakage

Maximum flow

Top loading New



No lubrication

One piece ball and

stem New

Hydromatics, Inc.

LIVINGSTON, N. J. • WYMAN 2-4900 • TWX = LIVINGSTON, N. J. 120

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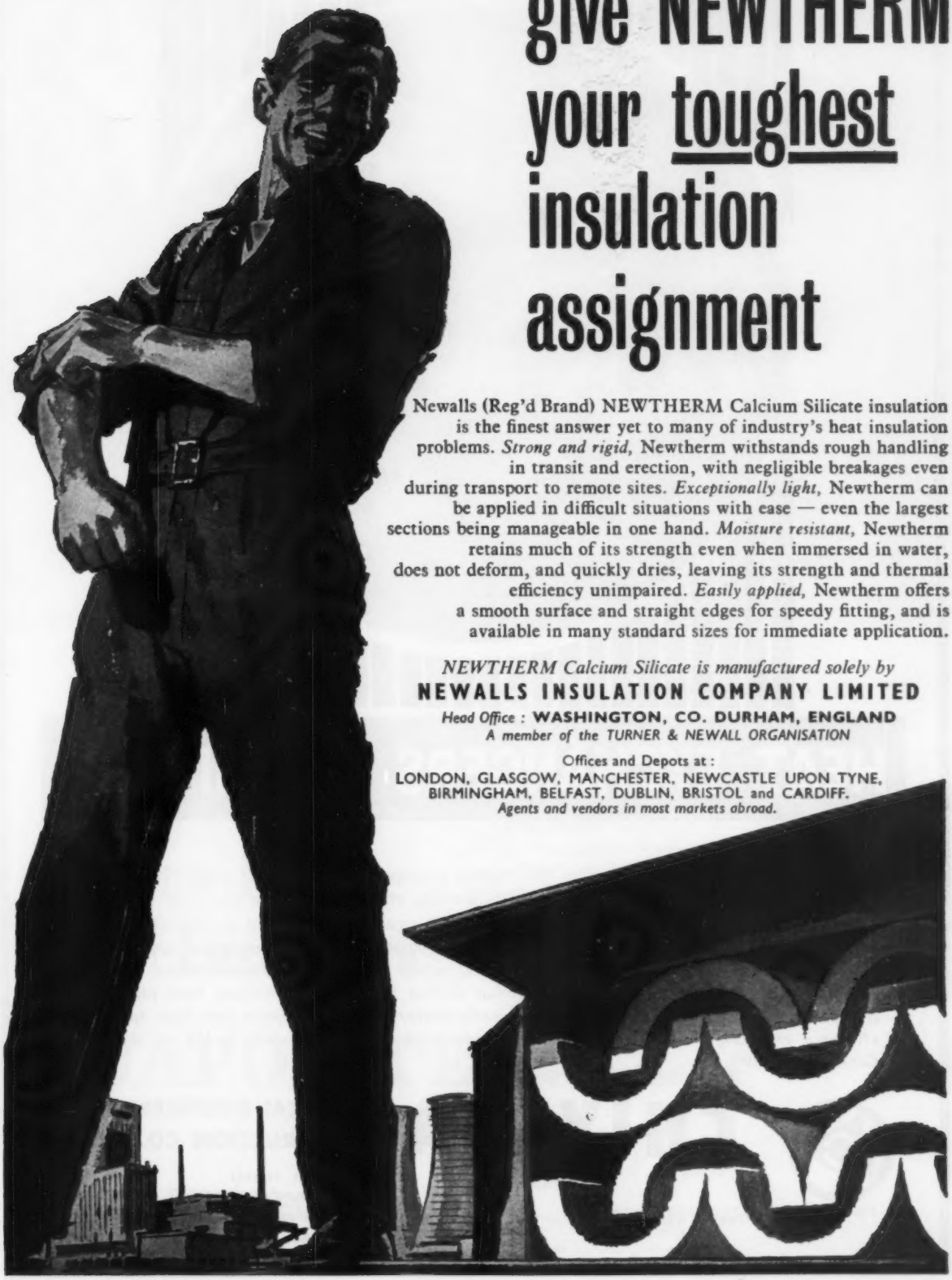
PERMIT #40
LIVINGSTON
NEW JERSEY

Hydromatics, Inc.
Livingston, New Jersey

Mail this postage-free card today



give NEWTHERM your toughest insulation assignment

Newalls (Reg'd Brand) NEWTHERM Calcium Silicate insulation is the finest answer yet to many of industry's heat insulation problems. *Strong and rigid,* Newtherm withstands rough handling in transit and erection, with negligible breakages even during transport to remote sites. *Exceptionally light,* Newtherm can be applied in difficult situations with ease — even the largest sections being manageable in one hand. *Moisture resistant,* Newtherm retains much of its strength even when immersed in water, does not deform, and quickly dries, leaving its strength and thermal efficiency unimpaired. *Easily applied,* Newtherm offers a smooth surface and straight edges for speedy fitting, and is available in many standard sizes for immediate application.

NEWTHERM Calcium Silicate is manufactured solely by

NEWALLS INSULATION COMPANY LIMITED

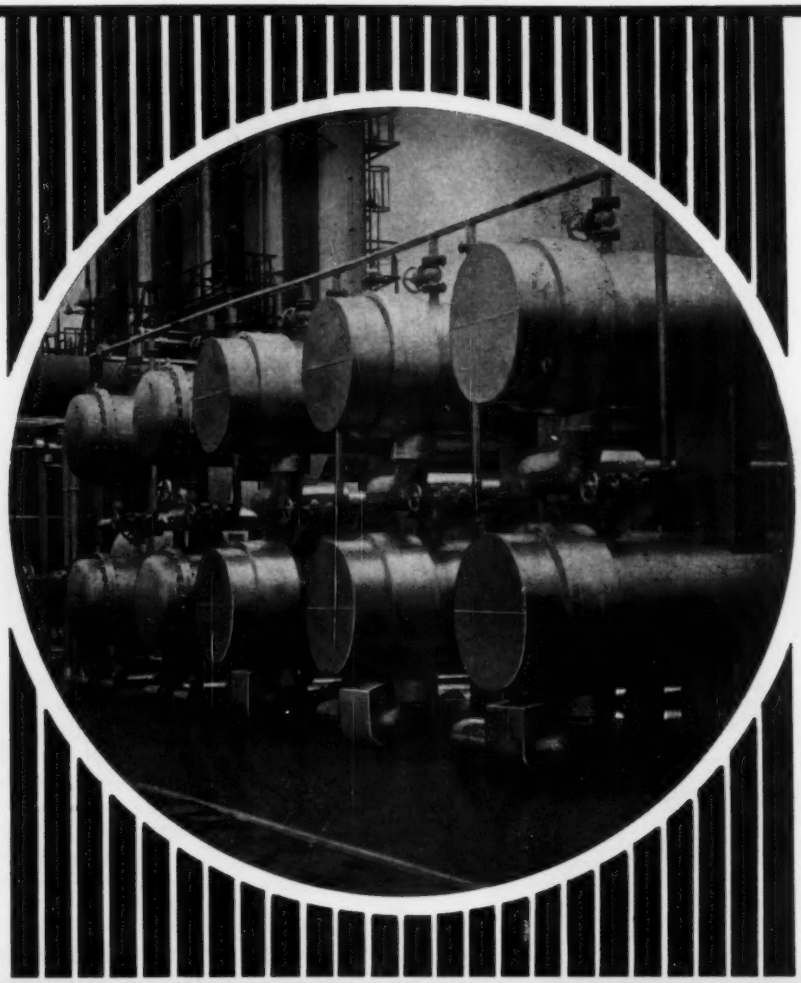
Head Office : **WASHINGTON, CO. DURHAM, ENGLAND**

A member of the TURNER & NEWALL ORGANISATION

Offices and Depots at :

LONDON, GLASGOW, MANCHESTER, NEWCASTLE UPON TYNE, BIRMINGHAM, BELFAST, DUBLIN, BRISTOL and CARDIFF.

Agents and vendors in most markets abroad.



HEAT EXCHANGERS by CHIYODA

The newest time-saving methods plus the highest standards of fabrication result in dividend-paying equipment that is characterized by its precise, efficient operation and long life. Heat exchangers, coolers, condensers, and other process equipment, standard or special, large or small, single or by the scores, are fabricated at CHIYODA's new Kawasaki Factory with the most modern fabricating and testing equipment, using fabrication methods backed by years of experience. With an integrated organization staffed by specialists in every field plus lower man-hour costs, CHIYODA assures clients of early delivery, low maintenance cost, high operating efficiency and long life. For your process equipment requirements anywhere in the world..... Contact CHIYODA.

CHIYODA

"Process Plants & Equipment Specialists"

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PRESIDENT A. TAMAKI
No. 3, MARUNOUCHI 2-CHOME, CHIYODA-KU
TOKYO, JAPAN
Cable Address: "CHIYOTAKA TOKYO"

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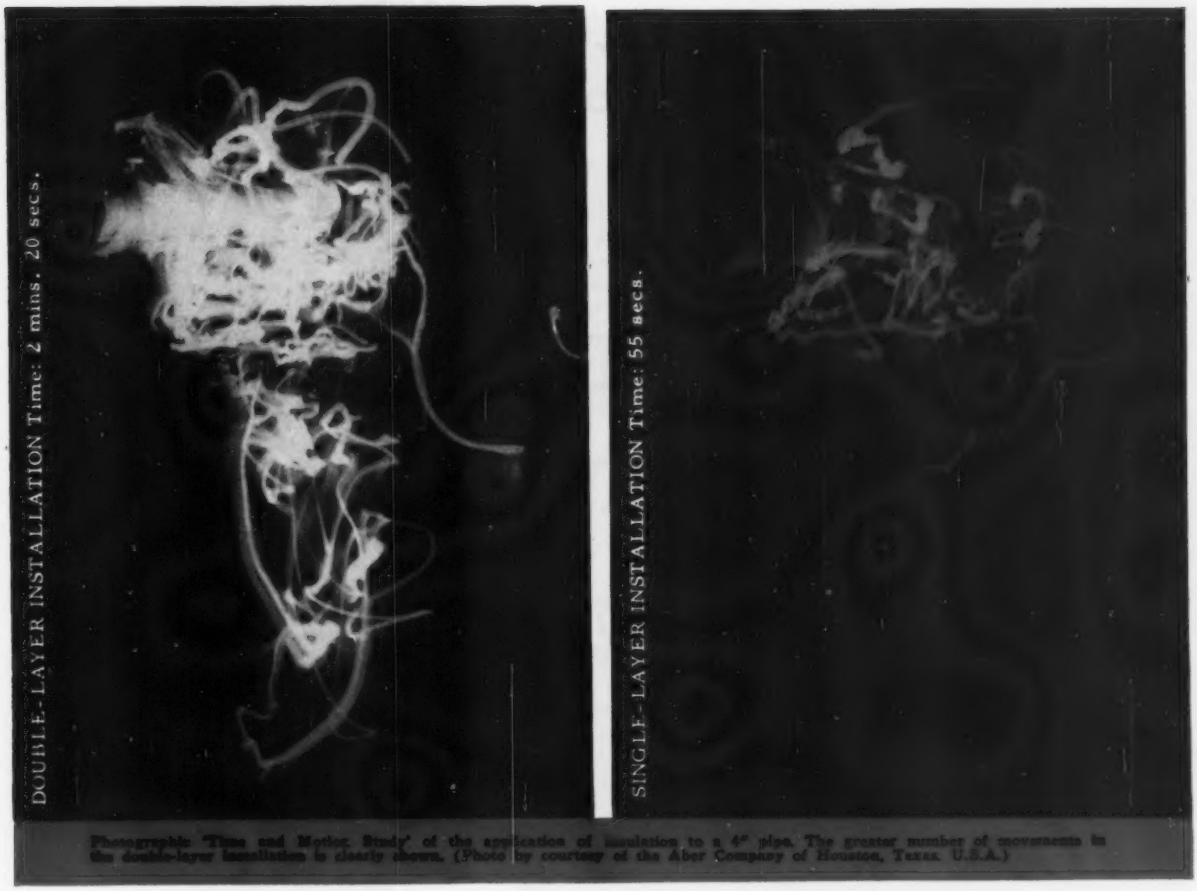

Photographic 'Time and Motion Study' of the application of insulation to a 4" pipe. The greater number of movements in the double-layer installation is clearly shown. (Photo by courtesy of the Aber Company of Houston, Texas, U.S.A.)

Insulation in a single layer! Caposite was developed by The Cape Asbestos Company to avoid the 'two-layer compromise' Caposite does it in one—saving considerably on installation time and costs. Caposite, the amosite asbestos insulation, is designed to withstand temperatures up to 1000° F. without loss of efficiency.

LOW JOINT LOSS

The fibrous edges of Caposite knit together at the joints giving a good heat seal and making staggered joints unnecessary.

EASY TO HANDLE

Its inherent strength makes it possible to handle Caposite in large sections for example at 2" thick for 30" n.p.s.—with very little damage and a further saving in installation costs.

One layer— Less work

CAPOSITE single-layer insulation

CAPE

THE CAPE ASBESTOS COMPANY LIMITED

114 & 116 Park Street, London W. 1, Grosvenor 6022
Cables: Incorrupt London

Enquiries in Canada to: Cape Asbestos (Canada) Limited, 200 Bloor Street East, Toronto, Ontario.
U.S.A.: North American Asbestos Corporation, Board of Trade Building, Chicago 4, Illinois.

TA 3548

For more data on advertised products, use Readers' Service Cards, last page.

FOR STAINLESS STEEL VALVES...

Langley are specialists in valves of first-class design in sizes from ¼" to 6". (and 8" & 10" bore in some types.)

Ex stock or quick delivery

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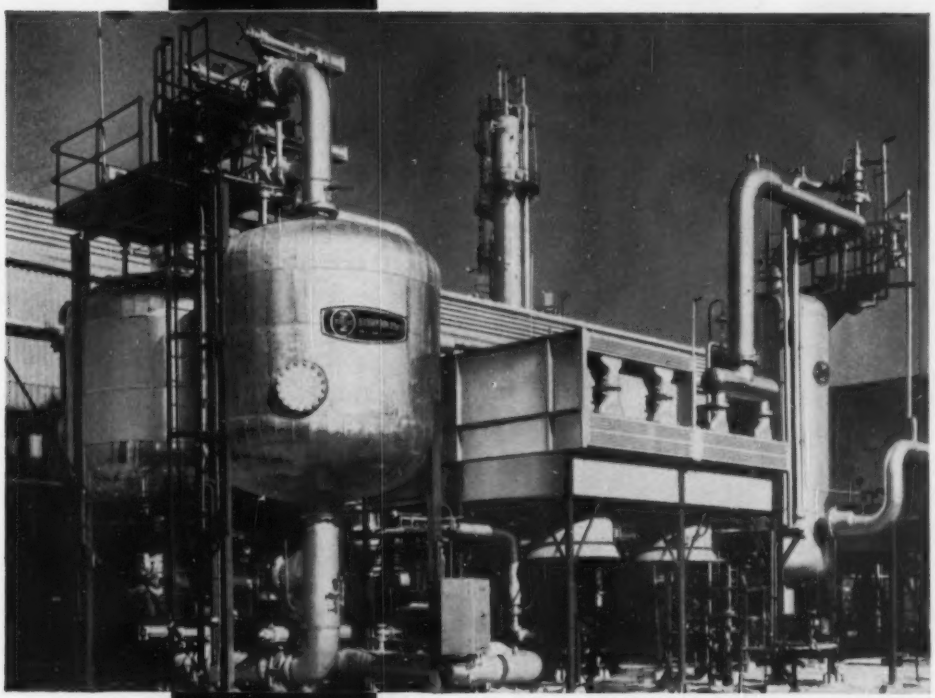
Birlec Process Gas Dryers



Birlec power former dryer installation at the Whitegate Refinery of the Irish Refinery Company Limited showing, from left to right, dual adsorber pressure vessels, air-cooled heat exchanger and scrubber tower.

at Whitegate Refinery

In the relatively new power former process for fuel enrichment, dry flue gas is circulated through catalytic reactors during the off-stream cycle. For the Irish Refinery Company Limited at Whitegate, Birlec has built a special dual adsorber dryer for the continuous removal of 240 lbs. of water per hour from the purging circuit. A flow of 18,100 c.f.m. is handled at 100 p.s.i.g. and the dryer maintains an outlet H_2O concentration of 15 p.p.m. (–40°F dewpoint). The plant, which is 20 ft. high and contains 10 tons of desiccant in each pressure vessel, also incorporates a scrubber and a filter for the flue gas and is designed to eliminate the use of cooling water.

An important part of Birlec's service to the petroleum and chemical industries is the design and fabrication of adsorption dryers that guarantee performance in process applications. Additionally, Birlec has wide experience of drying by refrigeration, absorption and compression. During 20 years in the field, Birlec has acquired unrivalled knowledge of costs, capacities, efficiencies, impurities and load fluctuations, and is particularly well equipped for advising on specialist problems with a technical content.

BIRLEC ADSORPTION DRYERS
DRY AIR & GASES

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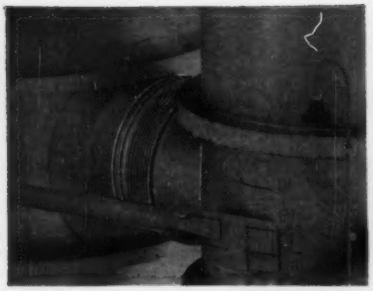
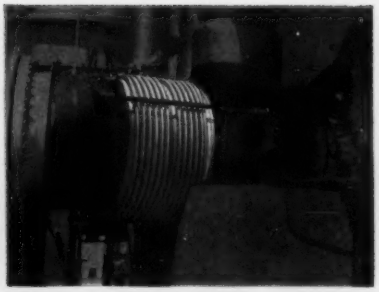
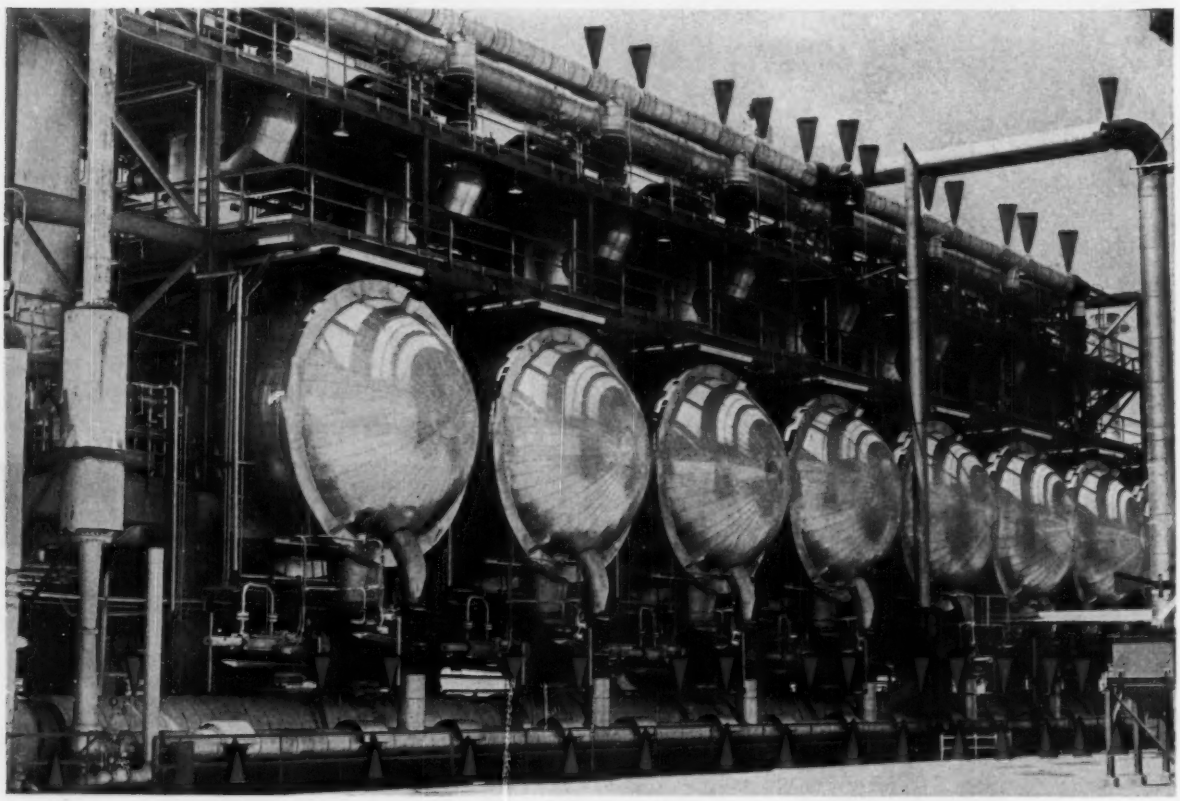


85½ in. dia. expansion joint connecting quench and pre-quench towers. Pinned structural ties permit expansion joint to absorb axial and differential vertical movement.



48 in. dia. expansion joint at compressor discharge. Double bellows permit large axial movement. Internal sleeve guide provides for stability, minimum pressure drop.

54 in. dia. hinged expansion joints in loop to pre-quench tower. They absorb 5⅜ in. vertical expansion and 7⅜ in. horizontal expansion due to 1200°F temperature in reactor header.



125 ZALLEA EXPANSION JOINTS, 125 demands for maximum reliability

Expansion joints, specially engineered and designed by Zallea, solve problems of space, heat and flow for Odessa Butadiene Co., Odessa, Texas.

Large-diameter piping (up to 72 in. dia.), with short, straight runs and critical flow conditions, posed new design problems. High temperature operation (1200°F) required minimum loading on sensitive equipment. Open-air construction, with few load carrying members dictated maximum stability of expansion joints with minimum use of external guides and anchors to support pipe weight and resist wind loading.

To solve these problems called for a competent, close-working team of process, piping and structural engineers from Fluor Corp. Ltd., design engineers from Odessa Butadiene Co., and application engineers from Zallea.

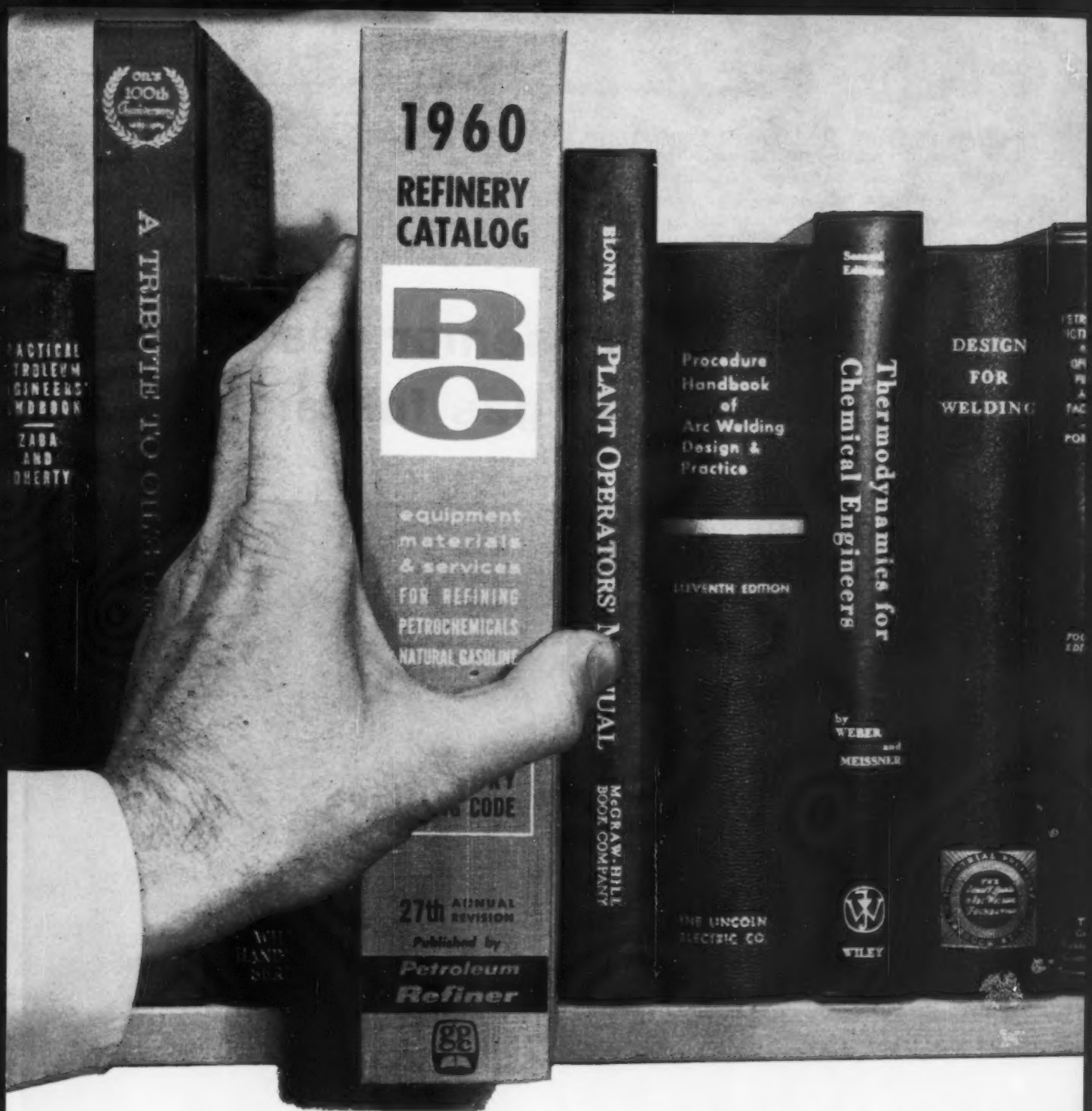
Result: A compact, reliable piping-expansion joint system that permitted containment of an efficient, 50,000 ton per year unit in an area whose largest dimension is a few hundred feet.

This is another example of how Zallea experience in handling critical, complex Expansion Joint applications can save time and money. For more facts, call us . . . or write for catalog 56.

ZALLEA BROTHERS, Taylor and Locust Sts., Wilmington 99, Del.

Zallea **FOR MAXIMUM RELIABILITY**

WORLD'S LARGEST MANUFACTURERS OF EXPANSION JOINTS



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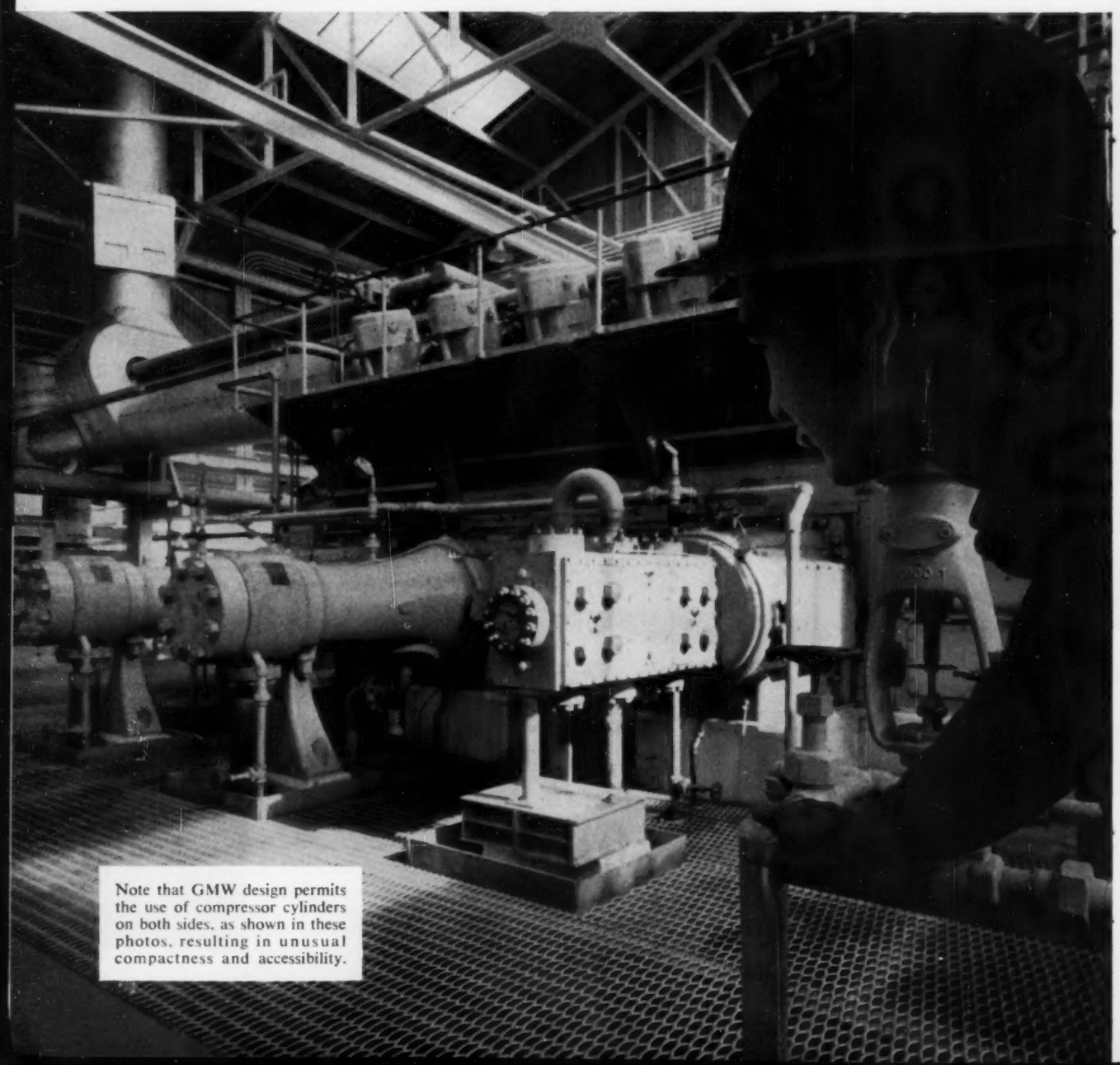
Report from American Cyanamid, Fortier Plant...

How Cooper-Bessemer gas engine boost synthesis gas for ammonia



Note that GMW design permits the use of compressor cylinders on both sides, as shown in these photos, resulting in unusual compactness and accessibility.

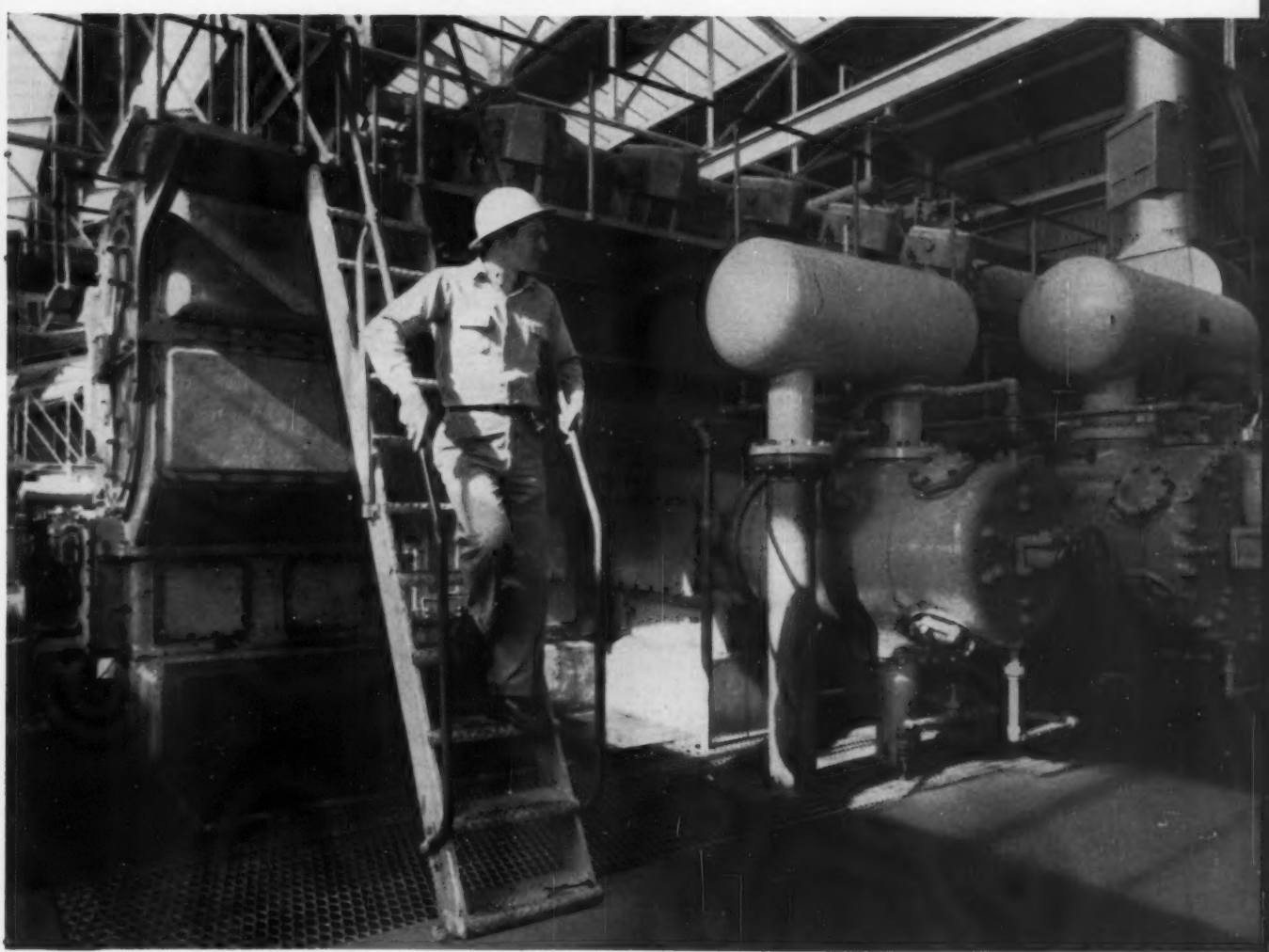
compressors to 5000 psi

These photos show both sides of one of the two Cooper-Bessemer 2500 hp GMW gas engine compressors at the Fortier Plant of American Cyanamid Company, Avondale, Louisiana. In the production of anhydrous ammonia, these 4-stage units compress 6000 cfm of synthesis gas from 60 psi to a discharge of 5000 psi. The left-hand view shows the high pressure cylinders; that on the right shows the low pressure side. The four stages of compression from 60 psi are (1) to 225 psi, (2) to 670 psi, (3) to 1500 psi, (4) to 5000 psi.

The two units have been operating since 1954, 24 hours a day, 340 days a year.

The anhydrous ammonia produced at the Fortier Plant is used by American Cyanamid in the manufacture of Acrylonitrile and is sold to fertilizer plants and other chemical companies.

Find out how Cooper-Bessemer can help *you* plan compression and power facilities. Write for copy of bulletin, "Cooper-Bessemer Equipment for Chemical Plants."



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For more than two decades UOP No. 5 Inhibitor has been leader of the most widely-used class of inhibitors—butyl phenylene diamine—the standard by which all other antioxidants are judged.

Introduced by Universal in 1938 as the first commercially used gasoline antioxidant of its type, UOP No. 5 was an instant success, was used by the Allied Forces in World War II in the bulk of their motor and aviation gasoline, and has since proved to be the most versatile inhibitor for catalytically cracked products, alkylates and catalytic reformates.

UOP No. 5 Inhibitor is used by refiners all over the world. So why take chances? Protect your gasoline, your customers and yourself with UOP No. 5.

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Correct selection and most effective use of petroleum inhibitors and additives involves expert analysis and consideration of many factors relating to your feedstock and methods of processing. As specialists for over a quarter-century, UOP is able to provide unparalleled field service, brought to you by a member of our staff of Product Sales Engineers. For detailed information on the UOP family of superior inhibitors and additives, call or write our Products Department.

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WHERE RESEARCH TODAY MEANS PROGRESS TOMORROW

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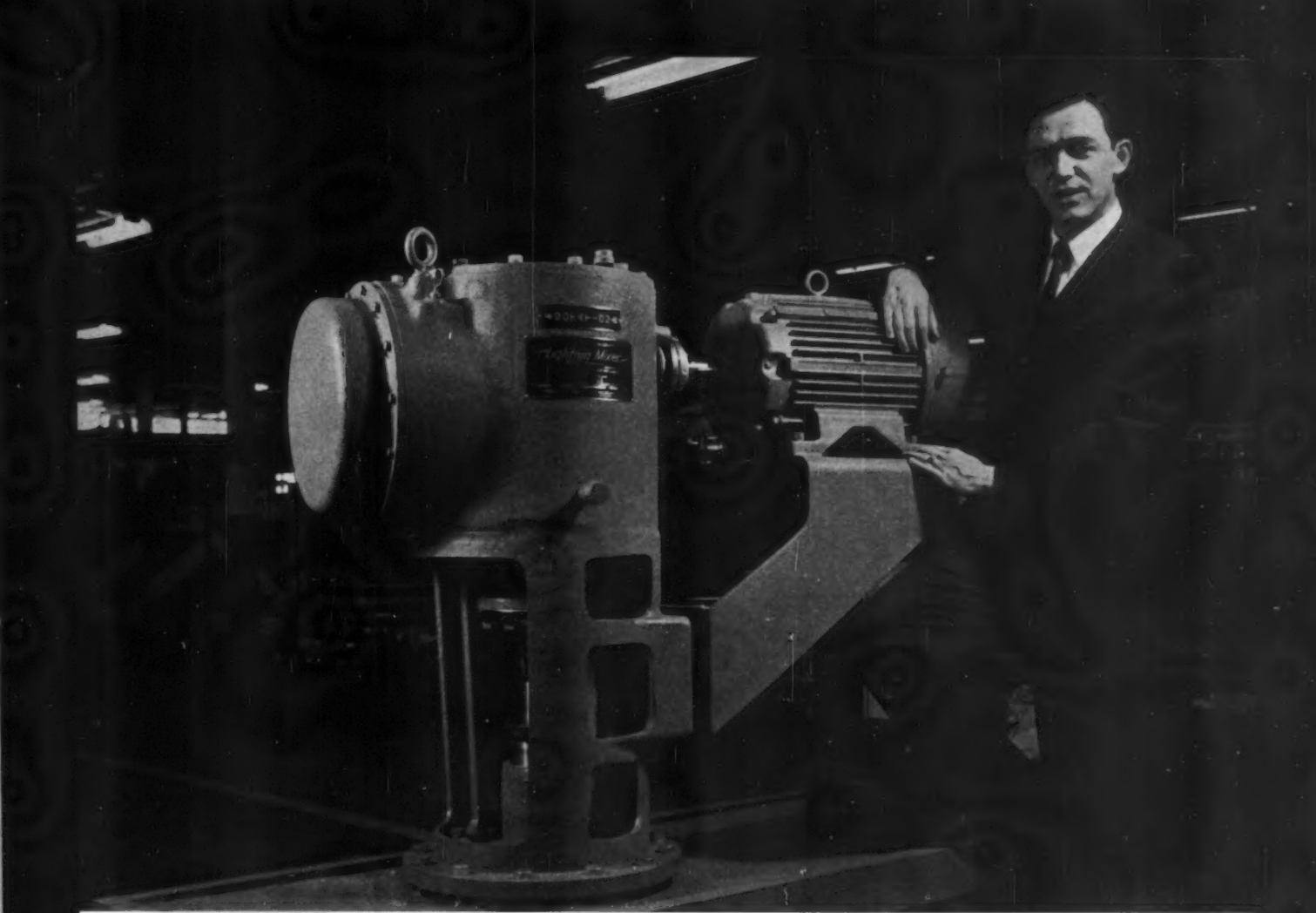

SERIES RE comes in a full range of mixer sizes and mountings for open or closed tanks.

NEW LOW-COST MIXER

Here's how to save money on fluid-mixing operations that don't demand the ultimate in shutdown insurance

In the new lower-cost Series RE LIGHTNIN Mixer, you get all the advantages of LIGHTNIN construction except for hollow-quill drive. The speed-reducer output shaft is coupled directly to the mixer shaft, rather than through a flexible coupling as in the regular Series E LIGHTNIN Mixer.

Because of this one difference, we DO NOT recommend the new Series RE line for critical operations in which an accidental overload on the mixer shaft could cause a costly drive failure. In such applications, our regular Series E design gives you maximum protection against process shutdown—a degree of insurance you get with no other mixer.

For any job that doesn't demand this high level of protection, you'll find the new Series RE LIGHTNIN Mixer hard to beat on first cost—and on performance.

It's the only mixer in its price range that gives you all these advantages:

1. Efficient right-angle drive—in all models
2. Low-headroom shape—in all models
3. Easy-to-get-at change gears—in all models

Plus: Precision bevel drive gears. Shaft bearings spaced to keep span and deflection to a minimum in accord with AGMA standards. Speed quickly changeable in case process requirements ever change. Splash lubrication throughout. Dry-well leak prevention. Many other refinements such as weatherproof oil-level gauge, weatherproof breather, clear-flow crankcase drain nipple, conveniently placed neoprene-covered grease fittings.

You can get the new Series RE in a full range of sizes, in your choice of *six* different mountings for open or closed tanks, and in literally hundreds of standard power-speed combinations. Wetted parts in carbon steel, 304 and 316 stainless steels are carried in stock.

Get the story now. Ask your LIGHTNIN Mixer representative to show you how new Series RE gives you more mixer than ever for the money—and where you can apply it for greatest savings. He's listed in Chemical Engineering Catalog and in the yellow pages of your telephone directory. Or write directly to us.

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MIXCO fluid mixing specialists

MIXING EQUIPMENT Co., Inc., 164-d Mt. Read Blvd., Rochester 3, N. Y.

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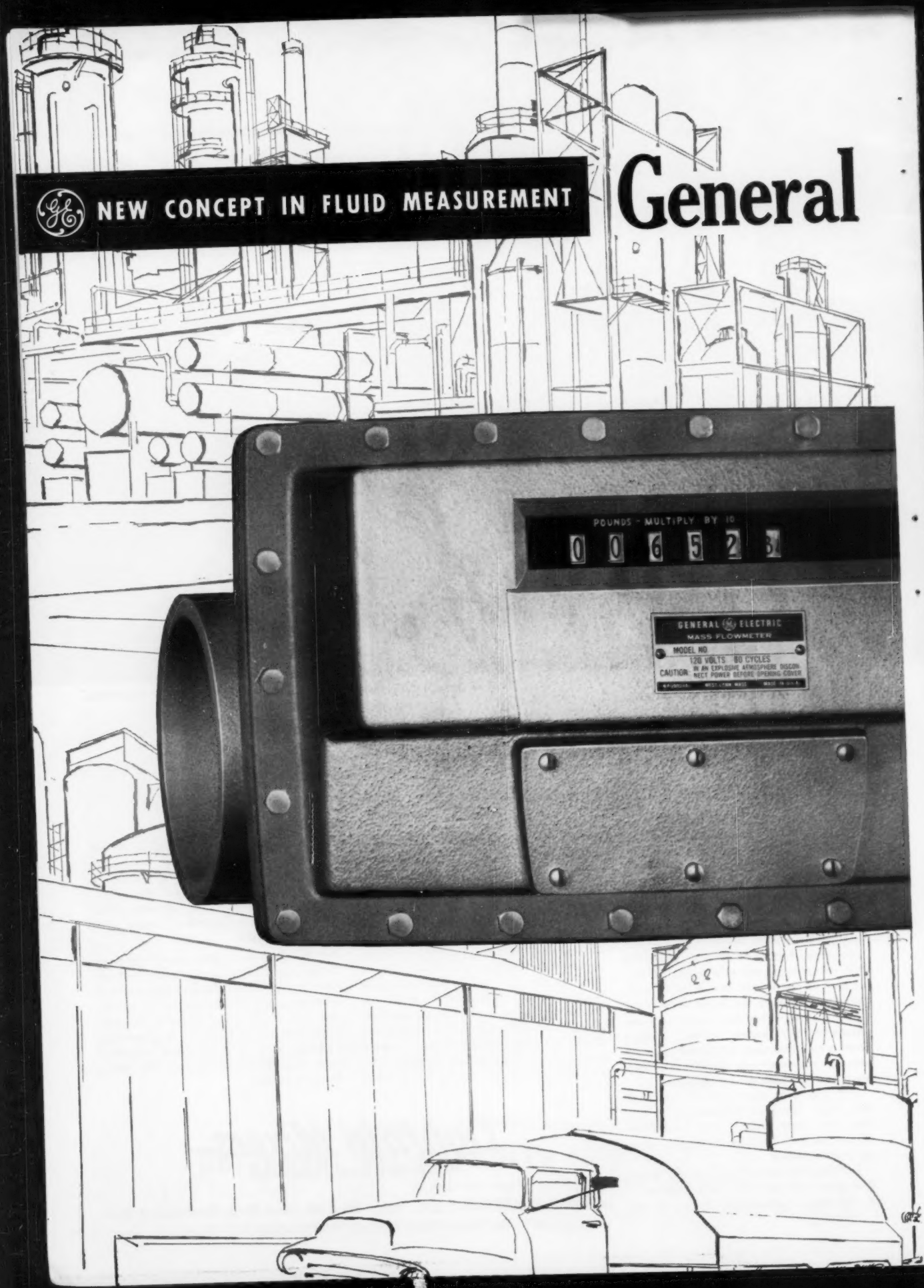
NEW CONCEPT IN FLUID MEASUREMENT
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MASS FLOWMETER
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CAUTION: IN AN EXPLOSIVE ATMOSPHERE DISCON-
NECT POWER BEFORE OPENING COVER

Electric Gyro-Integrating True Mass Flowmeter

ACCURATELY MEASURES FLOW OF LIQUIDS, GASES AND LIQUEFIED GASES . . . DIRECTLY IN POUNDS

This new General Electric meter provides continuous local or remote totalization and registration of gas and liquid flow by weight within ±1 percent accuracy over wide variations in flow rate, density, pressure, temperature and viscosity.

PROCESS FLOW MEASUREMENT—Ideal for applications in the petroleum, chemical, and petro-chemical industries, the new mass flowmeter completely eliminates time-consuming orifice calculations and possible costly errors in correcting volumetric readings for fluid variables. It does away with the need for recalibration when process and flow conditions change, too. And it puts an end to supercompressibility problems.

What's more, the new flowmeter lets you make complete and accurate material balances easily because it operates on a mass measurement principle and gives you your answer *in pounds*. No more measuring liquids in gallons or barrels, gases in cubic feet, then making tedious conversions in order to equate the two. Measurement of both by weight allows direct comparison.

LIQUEFIED GAS MEASUREMENT—You can measure the weight of truck and tank car loading of your liquefied gas products easier and faster with General Electric's new mass flowmeter than with present volumetric-type meters or expensive and cumbersome scale installations. The meter registers the total loaded weight directly in pounds. Then, operating from a battery-inverter power supply, the flowmeter can be used right on your truck when unloading, for easy and accurate deliveries. And no precautions are necessary to protect the meter from high velocity caused by "flashing."

An outgrowth of General Electric research into mass flow measurement, this new meter has already been proved on such fluids as natural gas, ethylene, Freon, liquid carbon dioxide, naphtha and jet fuel.

For complete sales and service information, contact your nearby General Electric Apparatus Sales Office, or write for bulletin GEA-6925A, Section 599-02, General Electric Company, Schenectady 5, N. Y. On applications in the natural gas industry, contact Black, Sivalls and Bryson, Inc., Kansas City, Missouri.

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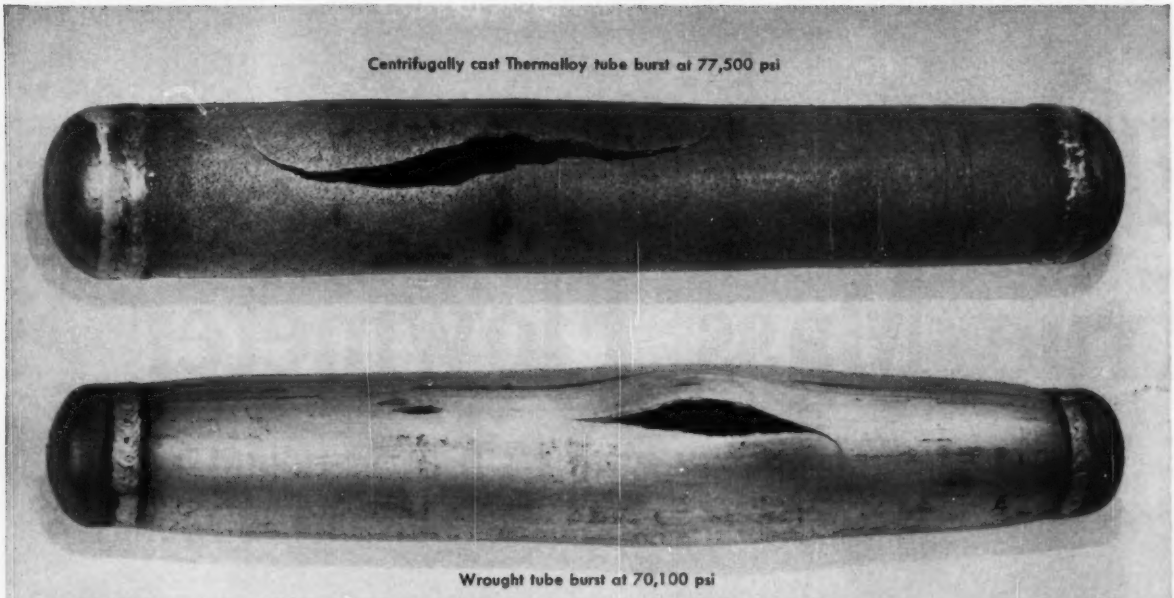

Burst tests prove 7,400 psi superiority of centrifugally cast Thermalloy® tubes

Hydrostatic pressure tests by Electro-Alloys established the rupture of a centrifugally cast Thermalloy tube section at 77,500 psi. Under the same conditions, wrought tubes of comparable section and analysis burst at 70,100 psi. These tests were conducted at room temperatures. Tensile tests show this strength margin increases substantially at the higher operating temperatures (1500° — 1800° F). The Thermalloy tube was tested *as cast*— without machining the inside or outside diameter. For further data, call your representative, or write Electro-Alloys Division, 2024 Taylor Street, Elyria, Ohio.

AMERICAN Brake Shoe COMPANY

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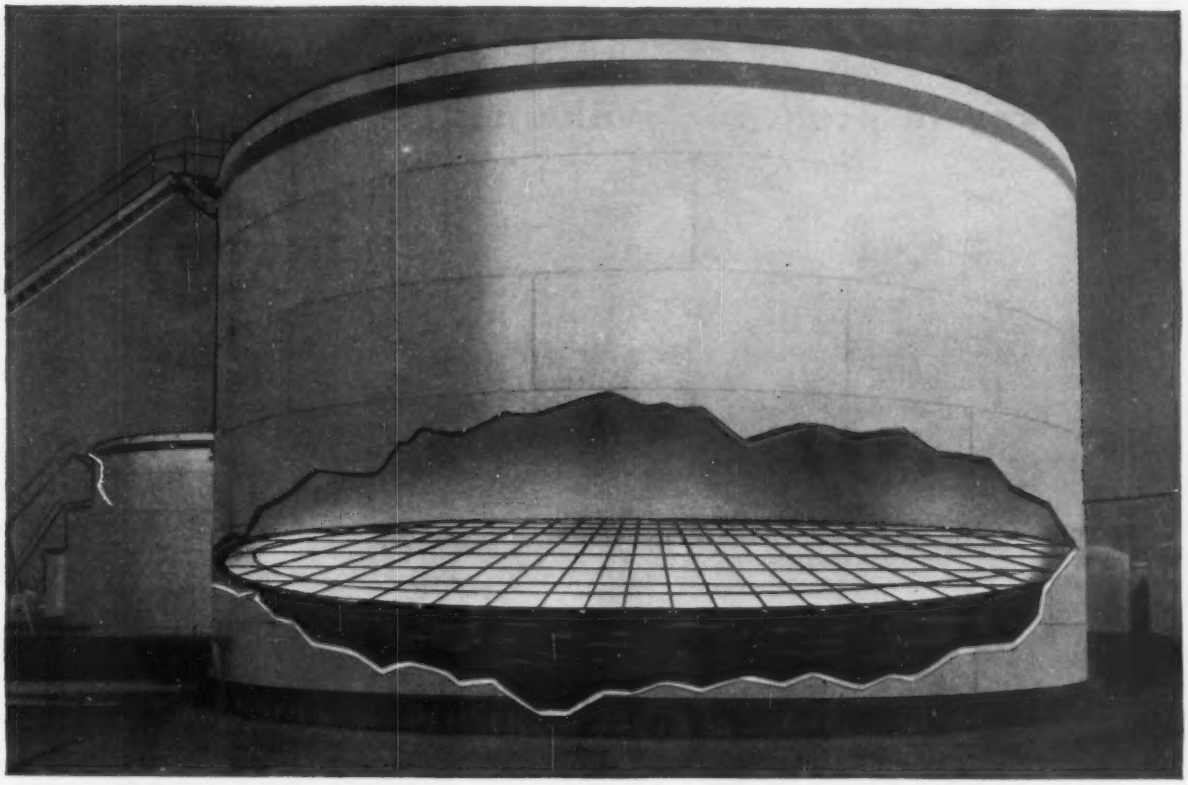
High-Riding Urethane Foam Tank Covers give Down-to-Earth Returns



LIGHT, STRONG . . . EASY TO INSTALL

Lightweight, easy to handle and assemble, prefabricated interlocking modules can be installed through shell or roof manhole. The tank need not be taken out of service. The radial outer sections, interlocked with rectangular sections, have end loops of urethane-coated flexible foam to form an efficient seal against the tank shell.

90% **REDUCTION IN VAPOR LOSSES!** That's the savings rigid urethane floating tank covers give . . . dollar and cents savings which pay for the installation in a few short months and continue as long as the covers are in service.

Flame-resistant, non-sparking urethane foam tank covers provide protection against filling and breathing losses in storage tanks for a wide variety of petroleum products, hydrocarbon volatiles and other liquid chemicals. The covers withstand temperatures of minus 94°F. up to 300°F. High puncture resistance and load carrying capacity minimize damage due to over-filling, obstructions or accidental misuse.

Regardless of tank sizes—pre-fabricated, sectionalized, rigid urethane covers are quick, easy and economical to install without special preparation or tools by regular maintenance crews. Completed covers are strong, lightweight and provide exact side seals under all operating conditions and temperature extremes.

For complete data and sources of supply for floating storage tank covers made from rigid urethane foam—write for Mobay Application Bulletin No. 5-F4.

f-9

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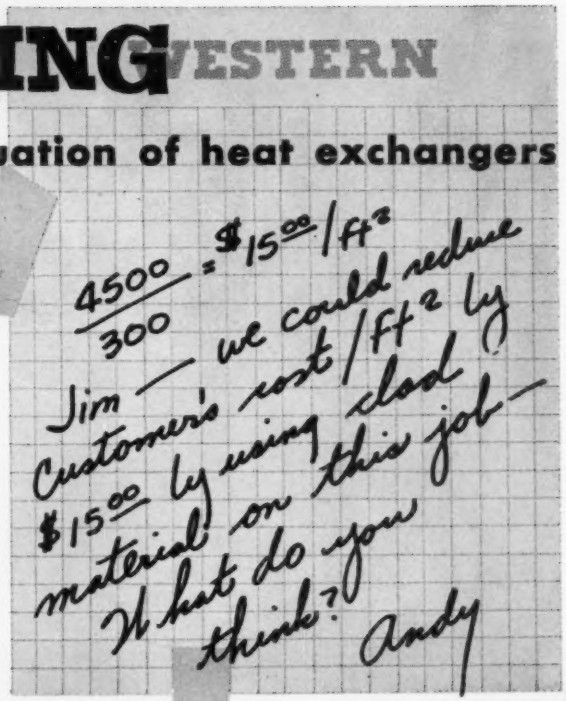
For more data on advertised products, use Readers' Service Cards, last page.

COST ENGINEERING

is the key to economic evaluation of heat exchangers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4500/300 = $15.00/ft²
Jim — we could reduce Customer's cost/ft² by $15.00 by using clad material on this job — What do you think?
Andy

Recognizing the importance of accurate economic evaluation of capital equipment to our customers' profit structures, Western's engineers have for many years applied cost-engineering principles to the design and fabrication of all Western Heat Exchangers.

This has special significance in continuous flow processes, where operations never cease and where operational and maintenance economies often spell the difference between profit and loss.

With an intimate knowledge of heat transfer technology as well as process operating conditions, Western has often been able to aid in such evaluation and long-range economy by suggesting short-cuts and improvements, while yet maintaining the efficiency and quality for which Western Heat Exchangers have gained respect.

Western's engineering staff takes professional pride in the accuracy of their evaluations, and they can be of great benefit to your own cost engineers when heat transfer is a factor in your process developments. Why not put them to the test?

WESTERN'S STAKE IN YOUR FUTURE

. . . is in the young engineers who are interested in the specialty of "cost-engineering" in heat transfer economics. To stimulate such thought, another of Western's "personal-professional-advancement" messages, partially shown at right, currently appears in several trade journals. A more complete treatment of the subject is available in pamphlet form, singly or in quantity, upon request.

One of a series appearing in OIL & GAS JOURNAL, CHEMICAL ENGINEERING, PETROLEUM REFINER, REFINING ENGINEER, CHEMICAL ENGINEERING PROGRESS.

serving the growth of the process industry

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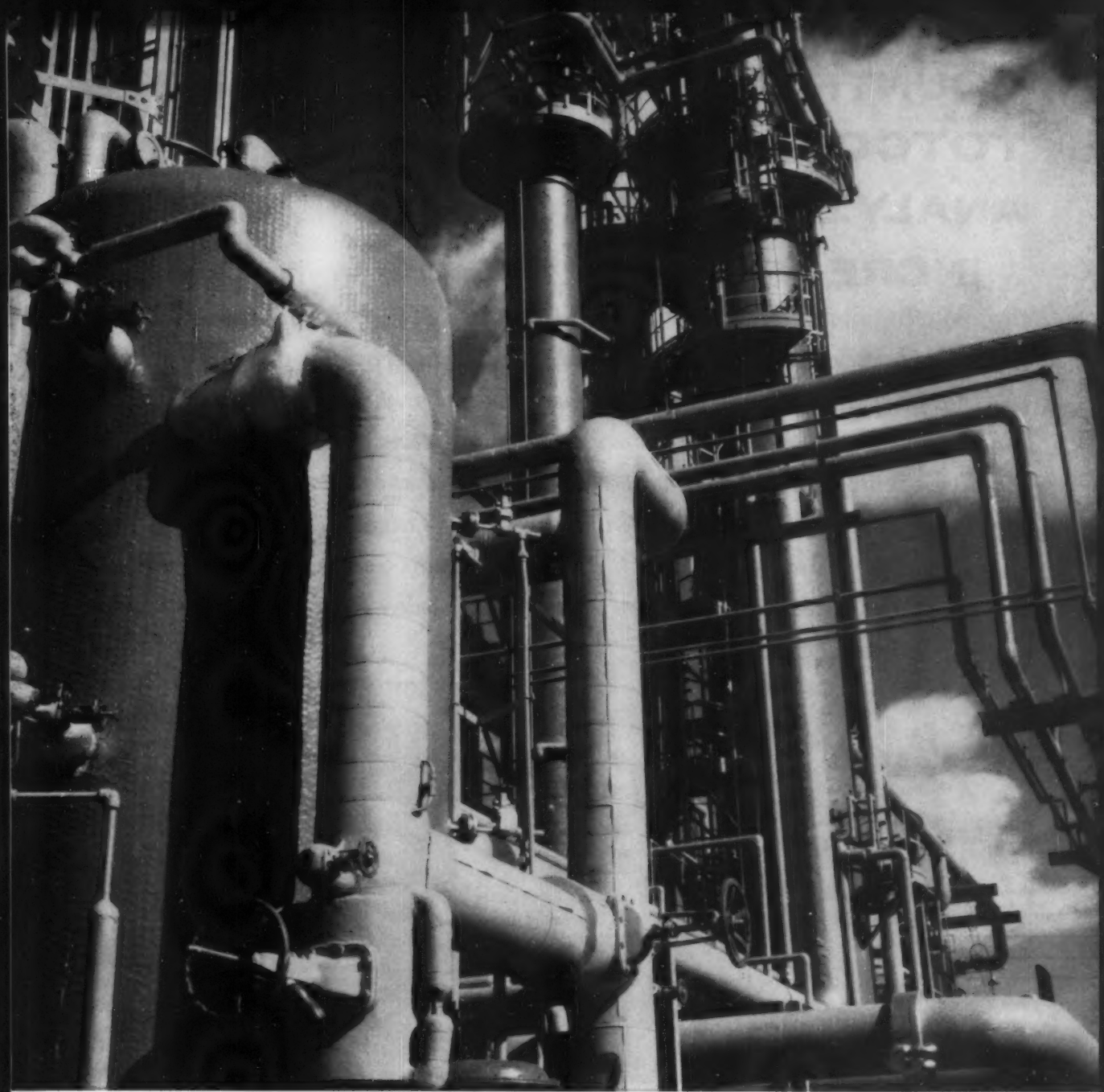
Design Economics of Heat Exchangers Furnish Basis for Heat Transfer Cost Engineering

The application of cost engineering practices in the accurate evaluation of capital equipment in the process industry is rapidly becoming more and more vital to the management of process companies, as margins of profit grow narrower.

For more data on advertised products, use Readers' Service Cards, last page.



UNRULY UREA TOES THE LINE FOR 6 SOLID YEARS

Another demonstration of how well Aloyco Valves withstand the worst kind of corrosive conditions... many more years of service are expected. That's why engineers at Deere & Company's giant $20 million Oklahoma plant (went on stream in 1954) put many more Aloyco Valves to work. They buy performance. You'll find Aloyco Stainless Steel Valves in scores of processing plants, wherever severe conditions present difficult valve problems. Want to know more? Write: Alloy Steel Products Co., Inc., 1303 West Elizabeth Ave., Linden, New Jersey. o.2

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COUNTRY-WIDE TESTS PROVE HOW TOTCO CONTINUOUS END-POINT ANALYZER CUTS CONTROL COSTS ...INCREASES YIELD

In major refineries from the East Coast to the West, the new Totco continuous End-Point Analyzer has demonstrated its ability to provide better control over product quality and yield. It quickly pays for itself and steps up profits. ■ This sensitive instrument continuously indicates the Engler End Point of a hydrocarbon stock or commodity in an operating range of 200° F. to 700° F. It delivers reproducibility within ±1°F., with results that correlate with ASTM D86 or ASTM D158. And its continuous analysis cuts the usual delays between quality change and compensating plant control... eliminates the time lag of batch analyzers or conventional laboratory tests. ■ Write or call today for further information. Request Bulletin 5900-11.

CASE HISTORY #1

Major Eastern Refinery

Use of the TOTCO End-Point Analyzer enabled this refiner to step up end-point specifications of reformer feed stock by 10°F with safety. Result: increased yield and a saving of over $200 a day. On the basis of this test, six additional Totco units were ordered!

CASE HISTORY #2

Major West Coast Refinery

Both TOTCO's End-Point Analyzer and Initial Boiling Point Analyzer were used here on a narrow-cut solvent. It was found that the analyzers kept yield on grade better than 99% of the time! Previous average with laboratory control was 90%.

CASE HISTORY #3

Major Mid-West Refinery

In this test, the TOTCO End-Point Analyzer was mounted in a trailer and used on a crude still to control first-cut products on stream. So successful was the test that the company ordered two additional Analyzers for use at other refineries.

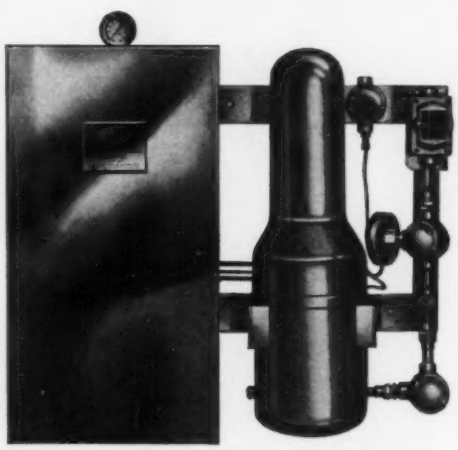
CASE HISTORY #4

Major Western Refinery

Demonstrating the versatility of the TOTCO End-Point Analyzer was this test where it was used to control the cut on heavy naptha. The test was a money-saving success, and the firm has since ordered additional units.

TOTCO CONTINUOUS INITIAL BOILING POINT ANALYZER

Totco also manufactures an Initial Boiling Point Analyzer. Write for Bulletin 1259-11 giving details and operating data.



TOTCO

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ROUTE TO:

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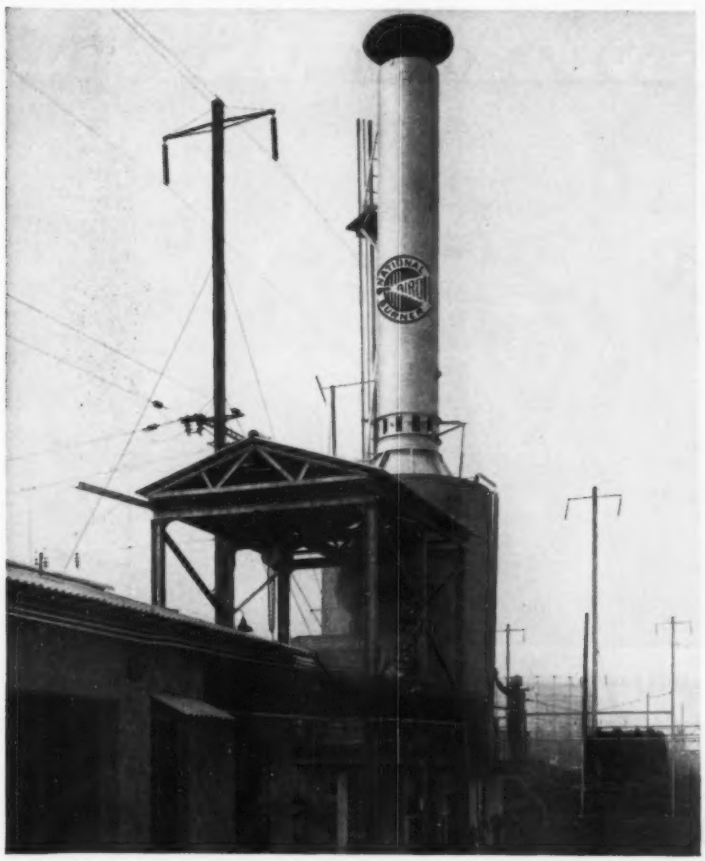
NAB Combustion Research Laboratory... Proving Ground for Burner Design Changes

Over the years, National Airoil Burner Company has expanded and improved its research and development testing facilities to meet changes in design requirements for oil and gas burners and accessories in a variety of industries, including petroleum, chemical, power and others.

This modern Combustion Research Laboratory provides an excellent proving ground, not only for design changes in existing burner designs, but for finding better solutions to new problems. For example, many reported difficulties in burning certain types of gas and heavy fuel oils, including viscous residuums, have been solved successfully for industrial installations throughout the world.

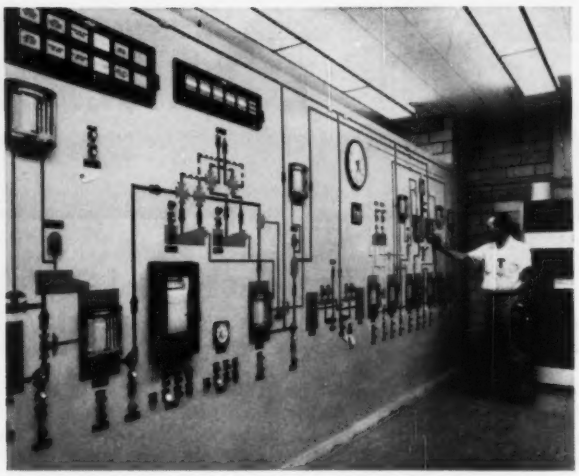
As a result of this careful testing, you are assured of a complete line of quality products, each performance-tested before it reaches your installation. Bulletin 759 shows how the many facilities of this modern combustion research laboratory can help solve your particular industrial burner problem. Write for a copy. No obligation, of course.



Typical Combustion Tests Conducted Recently:

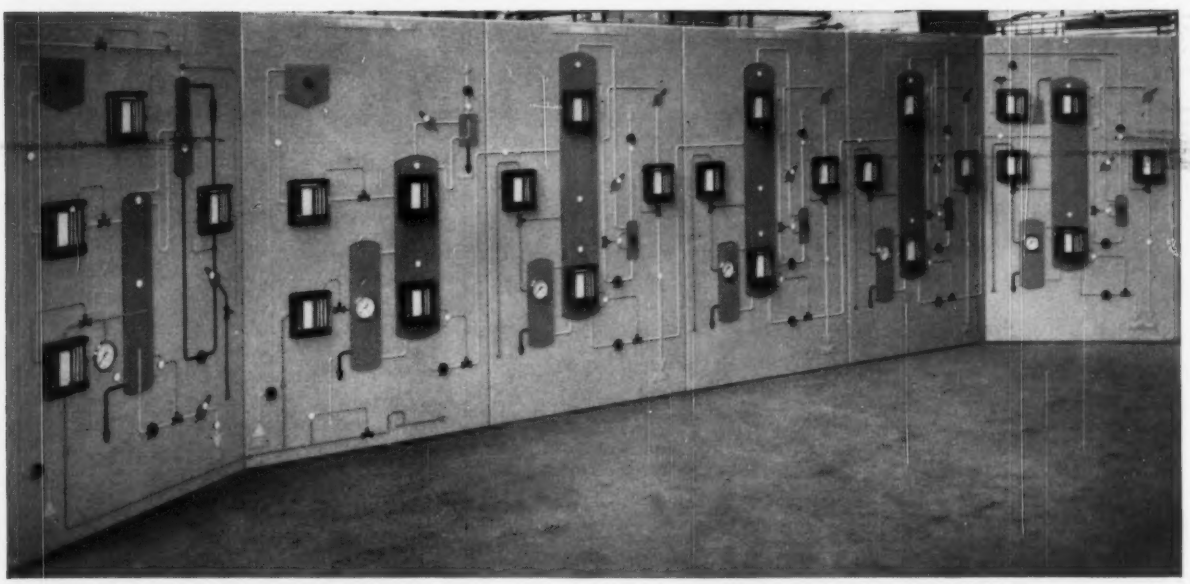
- For a large heater-furnace manufacturer for use in a major Caribbean petroleum refinery; vertical firing National Airoil Dual Stage oil burners of high capacity having a low atomizing steam consumption in a fresh water scarce area. Fuel is heavy, high temperature asphalt bottoms.
- For a large oil refining company and its fuel oil marketing organization; horizontally fully automatic rotary oil burners firing a mixture containing various proportions of otherwise unsaleable residues from propane deasphalting.
- Special vertical firing combination oil and gas burner units adapted to automatic combustion control for petroleum and chemical heaters-furnaces where maximum fuel economy is paramount along with a quick change-over of fuels.
- Vertical and horizontal firing oil burners using various grades of hydro carbon fuel gas under high pressure as the atomizing medium in place of, or alternately with, steam and compressed air.
- A series of steam atomizing #6 oil burning units for a wide turn down and employing uncommonly high oil pressure at the low capacity rates to improve the functioning of the automatic control, at the same time realizing a lower atomizing steam consumption throughout the entire wide range.
- Gun type mechanical atomizing oil burners with full automatic control on residual fuel oil or low pressure gas in a pressurized combustion chamber as applicable to direct fired air heaters and latest type pressurized boilers.
- Inspirating and non-inspirating gas burners with a varying percentage including up to 100% of hydrogen for vertical and horizontal firing in oil refineries and ammonia making plants.

One of several TRANSCOPE *panels in a large petrochemical plant in the South West.*



Part of an extensive TRANSCOPE *installation in a famous southern paper mill.*

"FINEST OPERATOR'S



TRANSCOPE Recorders on a graphic panel in a benzol distillation plant in England.

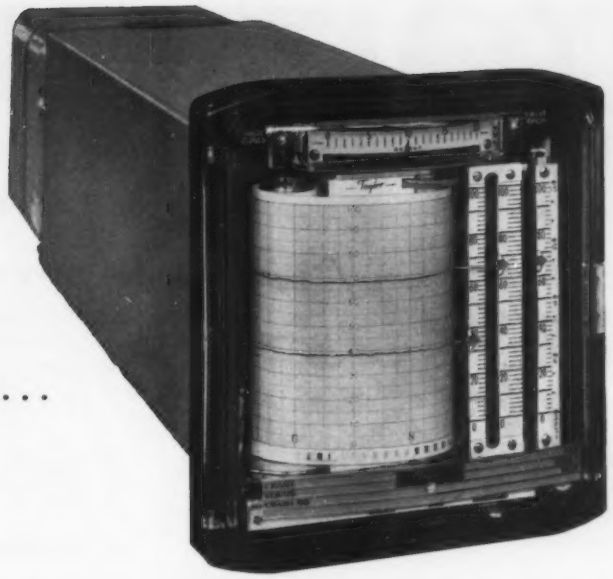
Taylor Instruments

For more data on advertised products, use Readers' Service Cards, last page.

No other recorder

puts so many features

in so little panel space . . .



TOOL YET DEVELOPED"

The Taylor TRANSCOPE® Recorder

It is now generally recognized throughout industry that the Taylor TRANSCOPE (90J) Pneumatic Recorder is the finest ever built for modern miniature-instrument panels. Of equal importance, if you're in the market for such instrumentation, the 90J will not be obsoleted for many years to come. In fact user reports, after two years of field service, are so outstandingly complimentary that we believe the name TRANSCOPE will rival that of the now famous 20-year-old Taylor FULSCOPE* line for obsolescence-free dependability. Here are some of the reasons why the 90J is going to be the most imitated recorder:

Servo-Operated Pens with 150 times greater power, assure unprecedented accuracy of records.

Unconfused Readability because chart record, pen and set-point are side-by-side. Target-type pens and pointers are easiest to see, particularly at a distance. 4" chart reads from left to right on rectilinear coordinates.

Optional Front-of-Panel Settings let you make control adjustments easier, quicker and better . . . from the front of panel . . . while recording!

Stays on Automatic Control while the plug-in recorder slide is removed for inspection, providing continuous fully automatic control.

Complete Indicating Control Station while recorder is removed. Optional switch lets horizontal gage at top of recorder show either process variable or output to valve.

Receives Three Variables to be recorded or indicated; unique, plug-in Set Point Transmitter allows continuous control. Available with Process Alarms with Memory Pointers; Automatic-to-Manual switching; Cascade or Process-output Switch, and many other features . . . all in one compact case.

*Reg. U.S. Pat. Off.

See your Taylor Field Engineer, or write for **Catalog 98286.**

Taylor Instrument Companies, Rochester 1, New York, and Toronto, Ontario.

MEAN ACCURACY FIRST

CONTACTOR NUMBER 1

AMINE PROCESS DESIGN AND OPERATING INFORMATION

Proper use of amines in well designed, correctly operated equipment is essential for efficient gas treating. Some of these important design and operating considerations will be discussed in this series.

Basic Rules for Reboiler Design

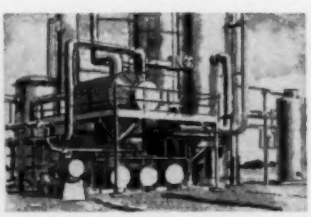
Since the reboiler is the hottest point in a system, maximum efficiency is possible only if these basic design principles are followed:

1. Two or more inlet and outlet nozzles should be employed. This prevents dead flow areas which promote corrosion.

2. Reboilers that operate liquid full are generally superior. They help prevent concentration of higher-boiling corrosive compounds in the reboiler.

3. Tube vibration should be prevented if possible. Condensate should be drained from tubes, long unsupported tube spans eliminated, and teflon inserts used to prevent baffle cutting.

4. Hot oil or direct fired reboilers should be avoided if possible. If they are used, it is mandatory to achieve high circulation rates on the amine side to prevent tube hot spots.



Solution Pressure Reduction

The care used in selecting the proper point for reducing pressure of amine solutions will pay dividends in long equipment life. It is always desirable to maintain pressure on the rich solution until after heat is interchanged with lean amine.

Since high pressure heat exchangers are quite expensive, other methods can be used for reducing point of pressure. For example: use a rich amine flash tank prior to interchange, follow by interchange at about 250-300 psig., and then reduce to still pressure. The flash gas (usable as auxiliary fuel) contains almost all of the dissolved hydrocarbons and little acid gas.

Valves for reducing rich amine solutions are subject to an abnormally high corrosion rate. *Stellite* works well for this service when used in conjunction with high stainless alloy body (316 or better). The valve should have large flow chambers and the inner valve should be as large as practicable.

Fluid Velocities

A fortunate property of ethanolamines is that they are mild corrosion inhibitors. They are also excellent film formers . . . but once formed, the film is not tenacious. An additional measure of corrosion inhibition is obtained in systems absorbing H_2S from a thick FeS layer that passivates the surfaces on which it is formed. High fluid velocities should be avoided at all costs since they destroy these forms of protection.

Avoidance of stream impingement onto tubes in heat exchangers is especially critical in rich amine streams.

Because diaphragm control valves are expensive, small valves are sometimes employed for solution pressure letdowns by swaging the line to fit them. This basically is *not* good practice, since valve and swage corrosion generally occur.

Minimizing Stress Corrosion Cracking

Since ethanolamines are likely to cause stress corrosion cracking, vessels and piping should be stress relieved after fabrication and welding on oil equipment. Care should be taken in erection of stress relieved equipment to prevent setting up mechanical or heat stresses.

Cases have been reported where columns had to be replaced after only 2-3 years operation because of stress corrosion cracking. In addition to stress relieving, stress corrosion cracking can be minimized by controlling process conditions, since cracking occurs only in a corrosive environment.

FOR MORE INFORMATION, look for future issues of Allied Chemical Contactor featuring articles on ethanolamines and glycols in gas treating operations.

We will gladly send technical data, delivery and price information on Allied Chemical Ethanolamines and Ethylene Glycols.

For specifications and local offices, see our insert in Chemical Materials Catalog, pages 475-482 and in Chemical Week Buyers Guide, pages 37-44.

BASIC TO AMERICA'S PROGRESS

Allied Chemical

NITROGEN DIVISION

Dept. C1-21-1, 40 Rector Street • New York 6, New York

2819

help maintain high purity in Xylene Splitter at Suntide

This Xylene Splitter at Suntide Refining Company in Corpus Christi, Texas, produces, on a charge of 1500 B/D, of mixed xylenes, an overhead product normally containing 1.0% orthoxylene and a bottom product containing 94% orthoxylene.

Consisting of two towers side-by-side, connected in series due to height limitation, Suntide's Xylene Splitter has operated with as high a feed rate as 1800 B/D. Each tower, 130 feet high by 10 feet—6 inches in diameter, contains 60 Koch Flexitrays . . . for a total of 120 trays.

Koch Flexitrays are the most dependable and economical devices yet developed for distillation, absorption, and stripping. On **your** next tower be sure to investigate **Flexitrays.** The extreme flexibility of this low-priced tray has resulted in its use in more than 1,000 non-captive installations.

'Continuing progress through research'

ENGINEERED PRODUCTS

for Petroleum Refining

COMBAT CORROSION PROBLEMS

Garlock LATTICE-BRAID† Teflon Packings are perfect on pumps and engines in petrochemical, oil and gas service. They are strong, long-lasting, chemically inert. Withstand temperatures ranging from −120°F to +500°F. Less gland pressure is required to effect an adequate seal, resulting in longer sleeve and packing life, less downtime. Catalog AD-131.

Garlock CHEMISEAL† Mechanical Seals with Teflon* bellows possess greater immunity to corrosion than other designs. Easy to handle and install, do not score shafts, engineered to give a life expectancy many times that of other seals. Available in standard sizes to fit all pump shafts $\frac{7}{8}$" to $2\frac{1}{8}$" shaft. Seals against all media in pressures to 100 psi at 75°C or 75 psi at 100°C. Catalog AD-164.

Garlock Teflon-jacketed Gaskets give you the advantage of using Teflon without sacrificing resiliency and deformability . . . particularly important on your glass-lined process equipment, standard metal flanges, and glass pipe flanges and fittings. Garlock offers four basic designs—slit envelope, milled envelope, formed shield, double jacket —and a wide selection of filler materials and thicknesses. Catalog AD-154.

Garlock GUARDIAN† Gaskets provide a safe, positive seal against high temperatures and pressures of steam, oils, gases, liquids. Gasket density, introduced during manufacture, assures dependable sealing under varying service conditions. Used at temperatures to 1050°F, pressures to 2500 psi . . . available in round, oval, square, flat side, diamond, pear and other shapes in practically any size. Large regional warehouse stocks are maintained at Camden, Cleveland, Houston and San Francisco. Catalog AD-104.

GARLOCK

For more complete information, call your Garlock representative at one of Garlock's 26 sales offices and warehouses throughout the U.S. and Canada. Or, write The Garlock Packing Company, Palmyra, New York.

Canadian Div.: The Garlock Packing Company of Canada Ltd.

Plastics Div.: United States Gasket Company

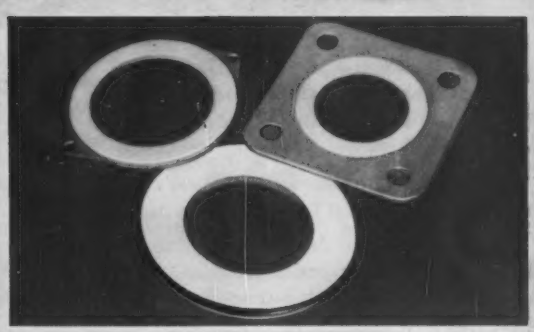
Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded & Extruded Rubber, Plastic Products

†Registered Trademark
*DuPont Trademark for TFE Fluorocarbon Resin

CHEMISEAL Mechanical Seals can be installed quickly and simply, offer leak-proof sealing without shaft wear . . . resist most reactive chemicals.

GUARDIAN Gasket V-shaped metal plies have an automatic spring action that reacts to variations in compression, internal pressures, and temperature changes. Assure leak-proof seal under most severe conditions.

LATTICE-BRAID Teflon Packing lasts far beyond the limits of other packings . . . gives maximum service over wide range of temperatures, pressures. Only Garlock can give you Lattice-Braid.



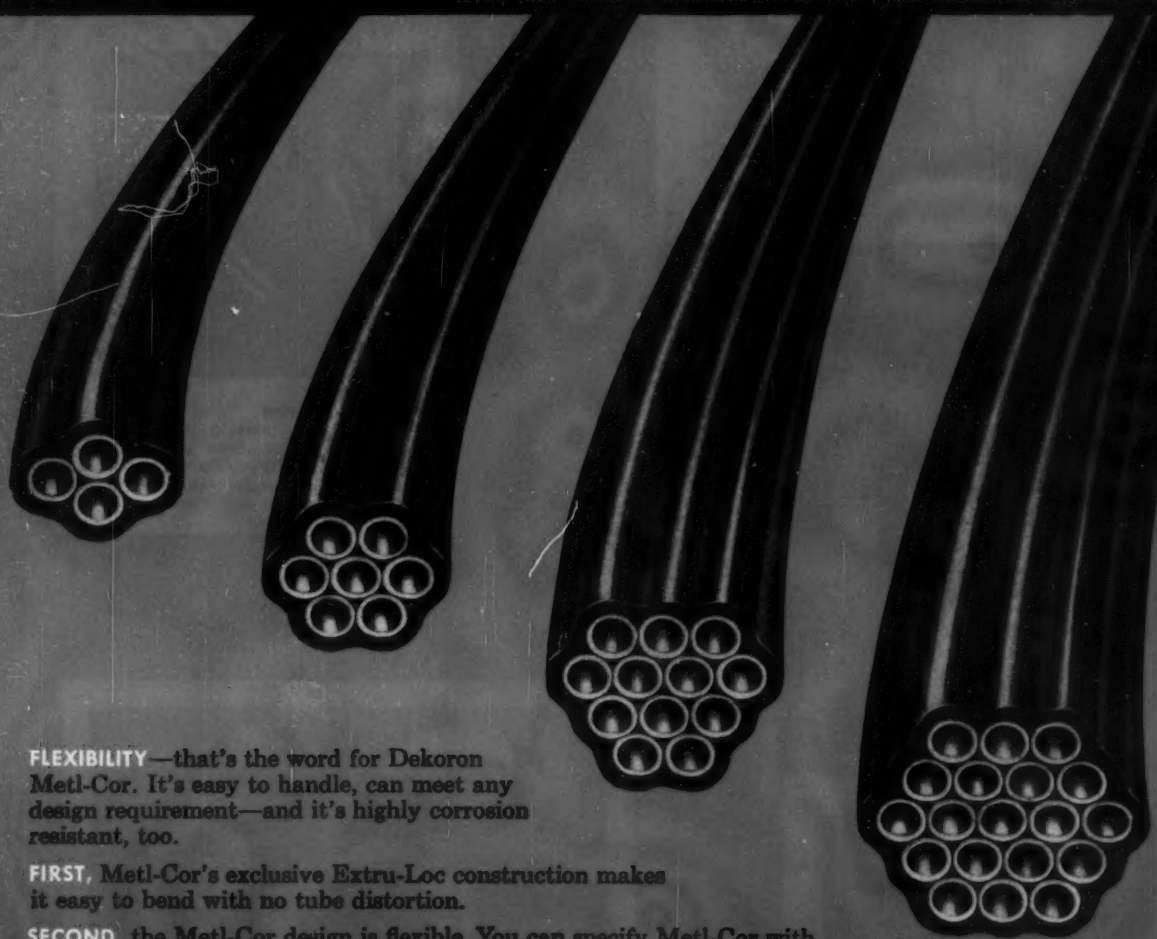
Teflon-jacketed Gaskets offer the advantage of applying Teflon without the loss of resiliency . . . ideally suited to pipes, flanges in processing.

DEKORON METL-COR MULTIPLE TUBE HARNESS

cuts installation costs

bends without distortion

solves instrument line corrosion problems



FLEXIBILITY—that's the word for Dekoron Metl-Cor. It's easy to handle, can meet any design requirement—and it's highly corrosion resistant, too.

FIRST, Metl-Cor's exclusive Extru-Loc construction makes it easy to bend with no tube distortion.

SECOND, the Metl-Cor design is flexible. You can specify Metl-Cor with core tubes in either copper or aluminum . . . in any standard or special OD or wall thickness . . . with almost any number of tubes in each bundle.

MOST IMPORTANT, no matter which type or size you specify—you get all the inherent cost-cutting savings and longer life that you pay for.

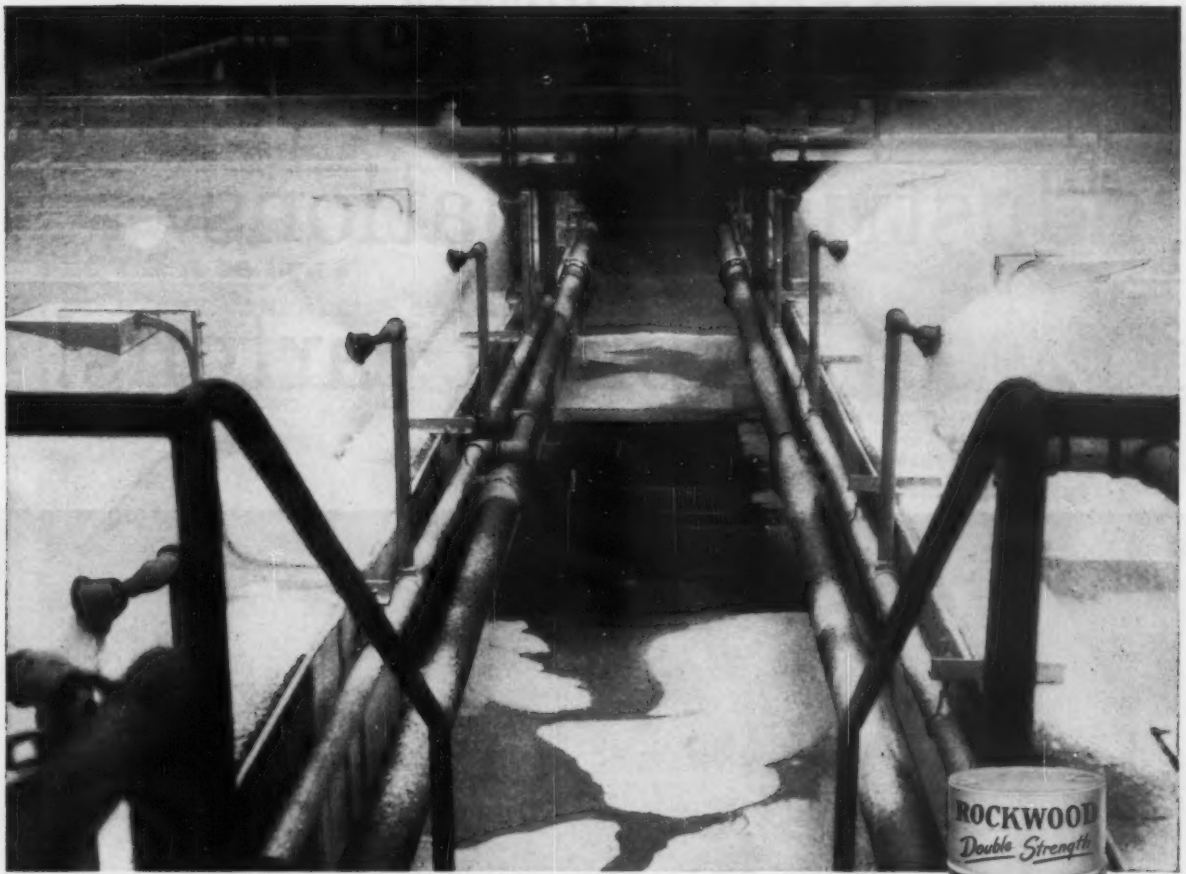
AA-1429

Dekoron® products

QUALITY • RESEARCH • SERVICE

SAMUEL MOORE & COMPANY

DEKORON PRODUCTS DIVISION • MANTUA, OHIO



Testing a Rockwood FogFOAM System that guards the oil separator pits in Cincinnati Gas & Electric Co.'s plant.

Double Strength FOAM Liquid Gives Double Protection. Three parts of Rockwood Double Strength FOAM liquid mixed with 97 parts of water and 900 parts of air form a fire-smothering blanket that quickly reseals itself. You pay for only three parts per thousand for this extinguishing agent that has proved its ability to put out spill fires in flammable liquids, with maximum speed and safety for personnel. Tested and listed by Underwriters' Laboratories, Inc. Branch Offices in all principal cities.

Here's high protection *against* low flash-point fires!

In any group of oil separator pits, the pit with the lowest flash point sets the danger mark for the entire area.

To installations of this type — and to many others endangered by fire — Rockwood FOAM and FogFOAM systems bring the surest, most dependable fire protection ever developed.

In the FogFOAM system shown above, protection starts with the heat detectors located around the pits. During any critical temperature rise these detectors sense the inception of fire. The signal is transmitted automatically — and the FogFOAM system goes into instant action.

Rockwood FOAM liquid, mixed with water and air, is then released through many FogFOAM heads over each pit. Within a few seconds a thick blanket of Rockwood FOAM completely covers the threatened area . . . *A disastrous fire has been prevented.*

Fire protection systems are custom engineered by Rockwood to meet the needs of every type of oil and gas installation. Send the coupon for details.

ROCKWOOD SPRINKLER COMPANY

A Division of The Gamewell Company

Engineers Water... to Cut Fire Losses

Distributors in all principal cities

ROCKWOOD SPRINKLER COMPANY
A Division of The Gamewell Company
510 Harlow Street
Worcester 5, Mass.

Please send me information on Rockwood fire-fighting products and systems.

Name.....

Title.....

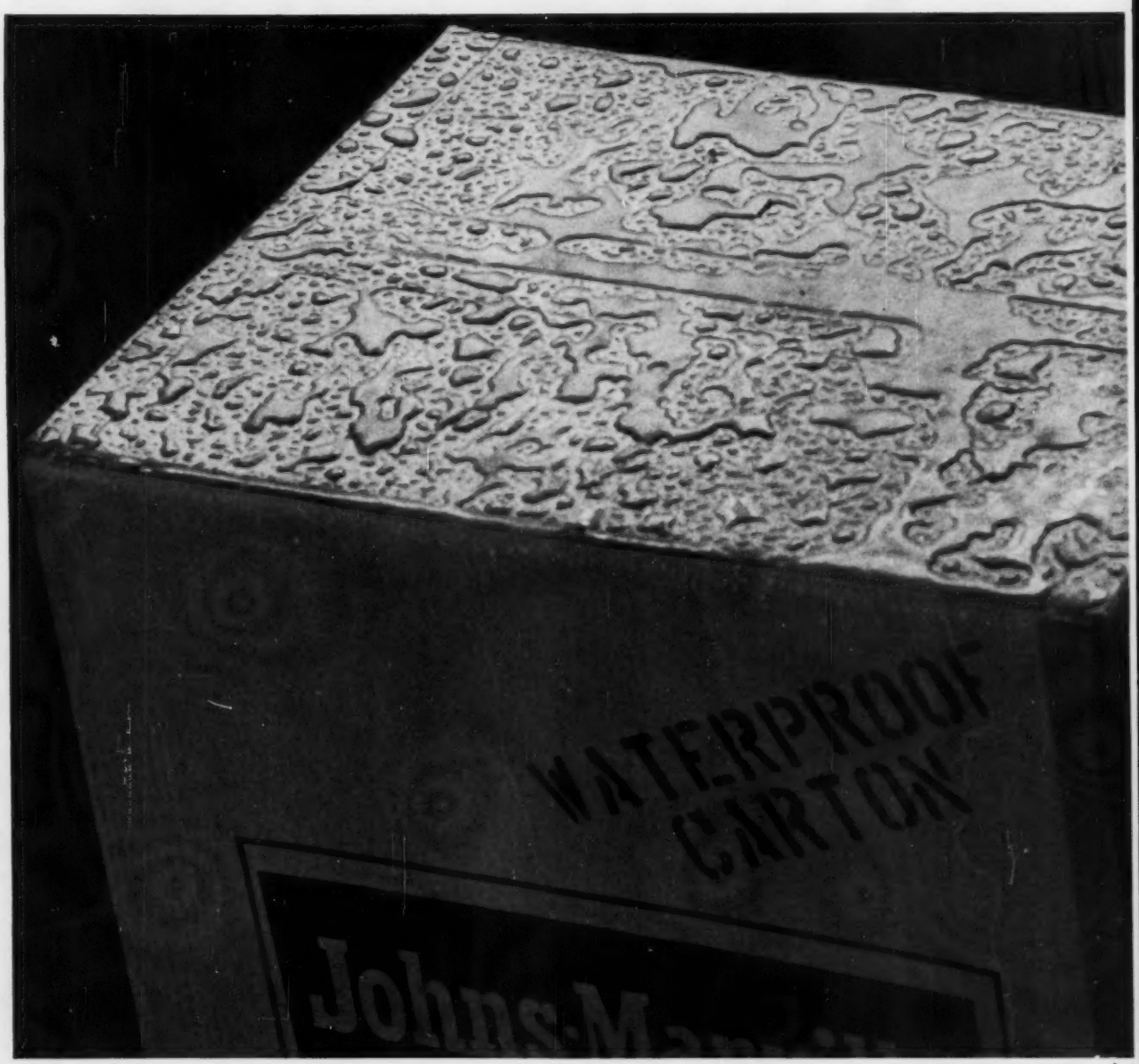
Company.....

City.....*Zone*..*State*.....

For more data on advertised products, use Readers' Service Cards, last page.

ANOTHER FIRST FROM JOHNS-MANVILLE

Industrial insulations in weatherproof cartons!



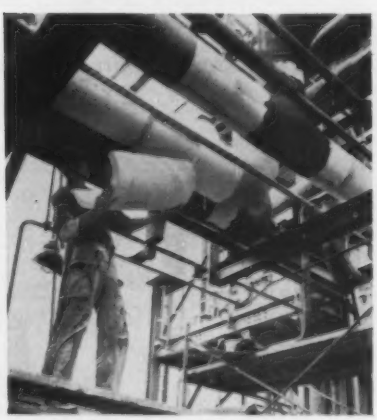
For more data on advertised products, use Readers' Service Cards, last page.

All these dollar-saving advantages for pennies more!

- **NO SHEDS TO BUILD**
- **NO HEAVY TARPAULINS TO HANDLE**
- **WEATHERPROOF FOR A MINIMUM OF 3 MONTHS**
- **SAVE TIME, WORK, MONEY ON THE JOB**

J-M THERMOBESTOS® Pipe and Block Insulation for temperatures to 1200 F., light in weight, top mechanical strength, low *k* factor.

J-M SUPEREX® Block Insulation is furnished in flat or curved blocks, and is recommended for equipment operating at temperatures up to 1900 F.



J-M 85% MAGNESIA Pipe and Block Insulation is designed for use up to 600 F. on heated piping and equipment. The standard for decades.

Now, thanks to a new and exclusive Johns-Manville carton, you can do away with on-the-job-site storage problems. Never mind the snow and rain. Just put the cartons on runners or skids—*and forget about weather problems.*

These cartons are proved by actual test to withstand rain and snow up to three full months! No need for sheds, lean-tos, tarpaulins or other protection. For only a slight premium, you save time—work—money. And only Johns-Manville offers you this plus value. Ask your J-M Insulation Contract Unit or your nearest J-M sales office.

JOHNS-MANVILLE

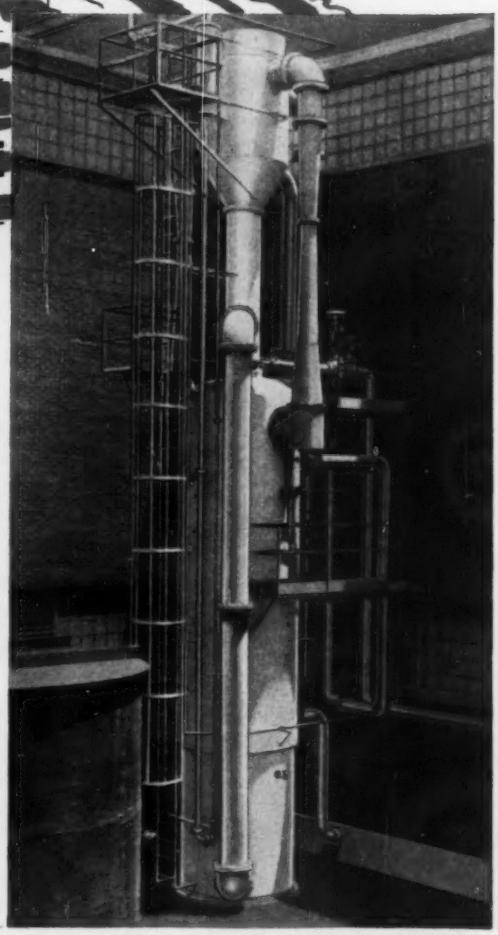
JOHNS MANVILLE JM PRODUCTS

AN INSULATION FOR EVERY COMMERCIAL AND INDUSTRIAL USE

For more data on advertised products, use Readers' Service Cards, last page.

"Water, water everywhere . . ."

. . . and not a drop under 95°!



Will this be your problem in July?

Perhaps Old Sam Coleridge's famous quotation may well apply to your situation. Graham Steam Vacuum Refrigeration offers you the best solution to your process water requirements.

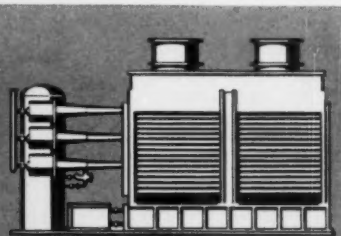
If you are going to be in need of colder water this summer, today is the time to plan for it.

Dependable, low in all costs, and tried and proved in hundreds of plants throughout the world.

Don't overlook Graham Steam Vacuum Refrigeration.

Write for Bulletin

A combination you cannot beat — a Graham Steam Vacuum Refrigeration System with the Aquadyne*



*Evaporative Condenser

Bowaters Southern Paper Corporation—largest, most modern newsprint mill in the South uses Graham Steam Vacuum Refrigeration.

Heliflow Corporation

GRAHAM MANUFACTURING CO., INC.

170 GREAT NECK ROAD • GREAT NECK, NEW YORK

Offices in principal cities and Canada

Factory: Batavia, N. Y. Other Graham precision-built products: Steam Jet Ejectors, Heliflow Heat Exchangers, Monobolt Heat Exchangers, Deaerating Heaters, Surface and Barometric Condensers.

HALLIKAINEN ANNOUNCES...

Boiling Point Analyzers:

initial to 10% and below 90% to end point

give

Immediate tower control, manual or automatic

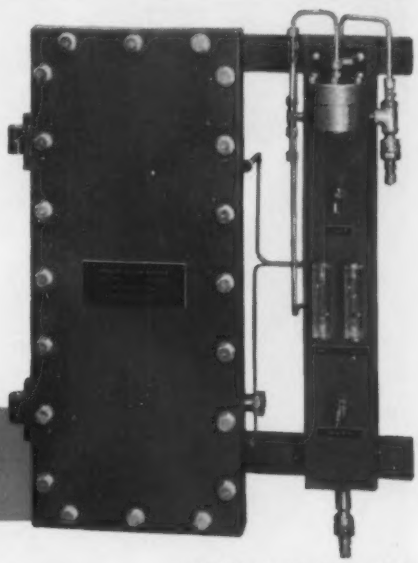
for

Lower control costs

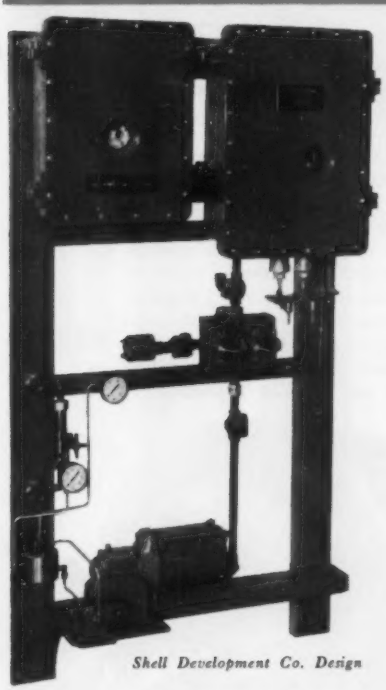
Better yields

Uniform production

Pay out { **30 to 60 days**



Shell Development Co. Design



Shell Development Co. Design

MANY SAVINGS come your way when you say **Goodbye to hand sampling and laboratory analysis of tower output.**

With the refinery-proved Hallikainen-Shell Boiling Point Analyzers, you are certain of lower control costs, better yields and uniform products that always please customers by meeting specifications.

In that way, these new instruments pay out in 30 to 60 days. After that, the savings show up every month in lower costs for you.

One instrument can be adapted to record either the initial boiling or the 10% point (200° to 400° F). The other, can be set from below 90% to the end point (200° to 600° F). Both monitor continuously.

Corrections in the tower can be made immediately—either manually or by an automatic signal fed into the tower control. Compare that with the tower stream going wrong for hours before the usual lab analysis can detect it!

These Hallikainen Instruments —proved accurate, reliable and safe—operate with a **constant sample flow.** Aside from changing the recording chart daily, little attention or maintenance is needed.

Write for all the technical facts on the Hallikainen-Shell Boiling Point Analyzers and then decide for yourself how these instruments can save money for your refinery.

HALLIKAINEN *Instruments*

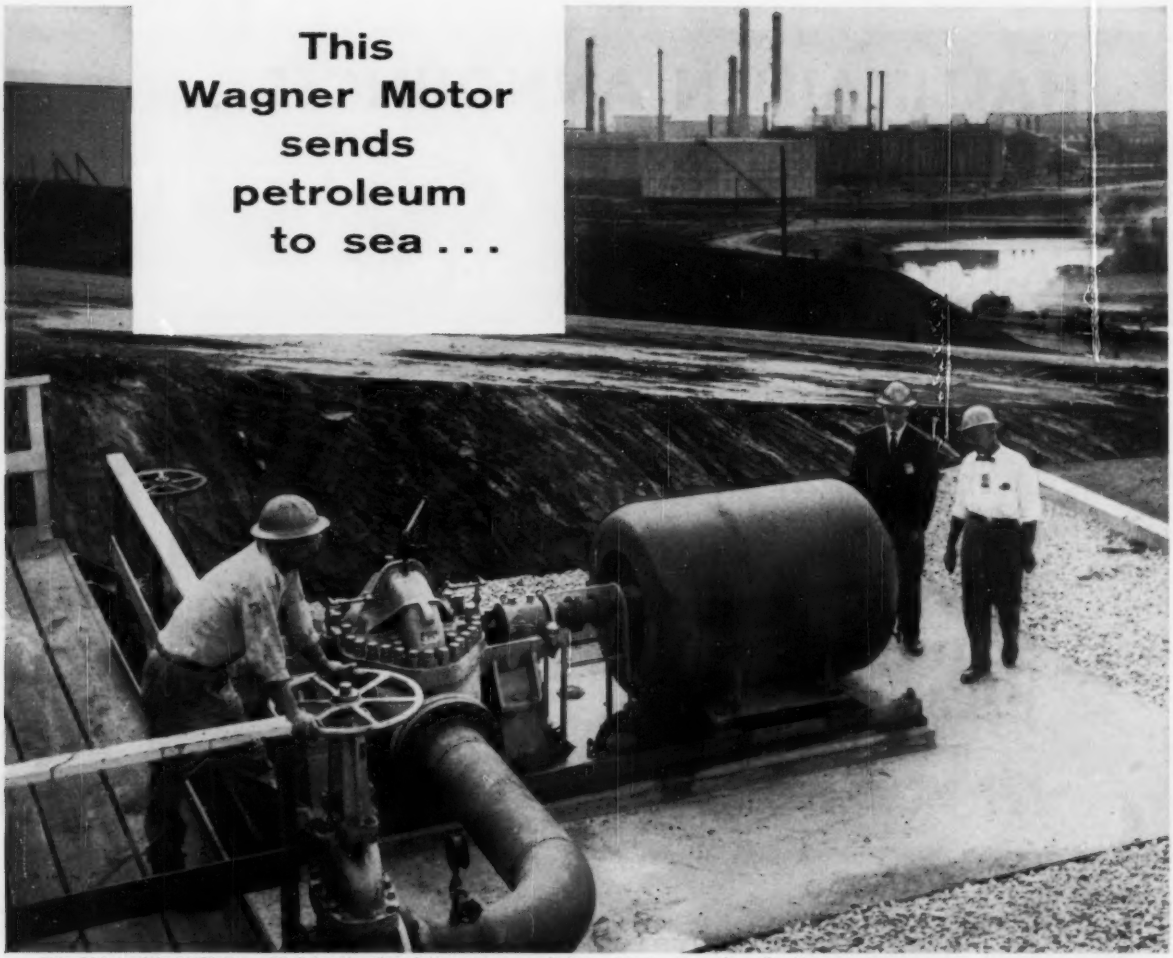
1341 Seventh Street **Berkley 10, Calif.**

Phone: LAndscape 4-1757

Other Hallikainen Products:
Continuous Vapor Pressure Analyzer, samples vapor pressure in stream—Continuous Viscometer, reduces lab analysis, gives better control—Sulfuric Acid Analyzer for sulfuric acid alkylation plants—Continuous Color Analyzers. Write for literature.

For more data on advertised products, use Readers' Service Cards, last page.

This Wagner Motor sends petroleum to sea . . .



This 500 hp WAGNER Type ZP Tube Ventilated Motor pumps oil from storage to tankers 2 miles away.

Big job, moving petroleum products to market. Standard Oil of California does it well . . . helped, at its El Segundo Refinery, by this 500 horsepower Wagner Tube Ventilated Motor. This explosion-proof motor's job: provide the power to pump crude oil from storage tanks down to the sea—and waiting tankers—two miles away.

Starting oil on a bon voyage is just one of many heavy-duty jobs performed by Wagner Tube Ventilated Motors. They also power big fans, blowers . . . any heavy-duty application that must be operated for long periods of time without a shut down.

These motors have fabricated steel frames that contain a series of tubes (as shown in photo below) through which cooling air is forced by an external blower. Internal blowers, one at each end of the rotor, circulate the warm air inside the motor through ducts in the rotor and stator and around cooling tubes. This effective cooling system holds the operating temperature of the motor within specified limits to lengthen motor life.

Whatever your motor requirements—large or small, for plant or product—Wagner can supply a standard motor or build a special motor to fit your needs. More than 65 years of constant research and development in electric motor design have made Wagner a name you can depend on. Call your nearby Wagner Sales Engineer for an analysis of your next motor application. There are Wagner branches in 32 principal cities.

WM60-11

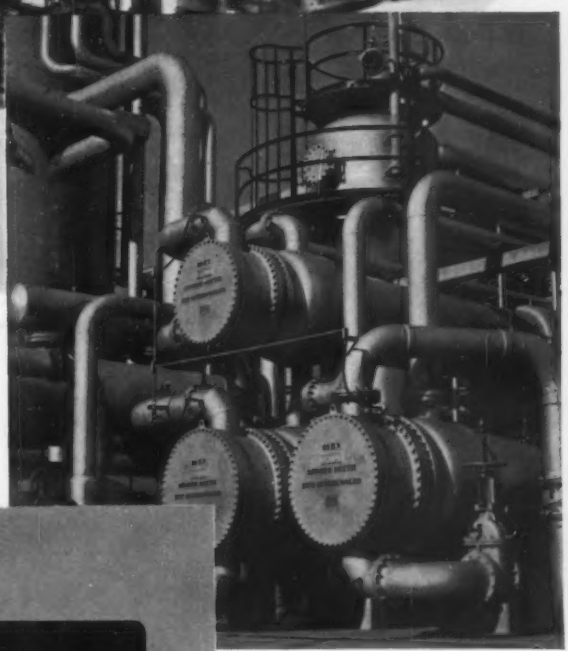
BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

Wagner Electric Corporation

6458 PLYMOUTH AVENUE, ST. LOUIS 33, MISSOURI

SERVING 2 GREAT GROWTH INDUSTRIES—*ELECTRICAL • AUTOMOTIVE*

where trouble-free performance is a matter of pride...



many heat exchangers are tubed with...

SCOVILL®

"the refinery of the future"

HEAT EXCHANGER TUBE

Tidewater Oil Company's showplace installation in DELAWARE, first in a new generation of oil refineries and the largest ever built at one time, also features some of today's finest examples of modern heat.exchanger equipment.

The plant was engineered and designed by Tidewater and C. F. Braun & Co., who were also the builders. Selection of Scovill Cupro-Nickel, 30% Heat Exchanger Tube was based on a well-proved formula for trouble-free heat exchanger performance . . . Scovill craftsmanship in tube production plus Scovill Technical Services.

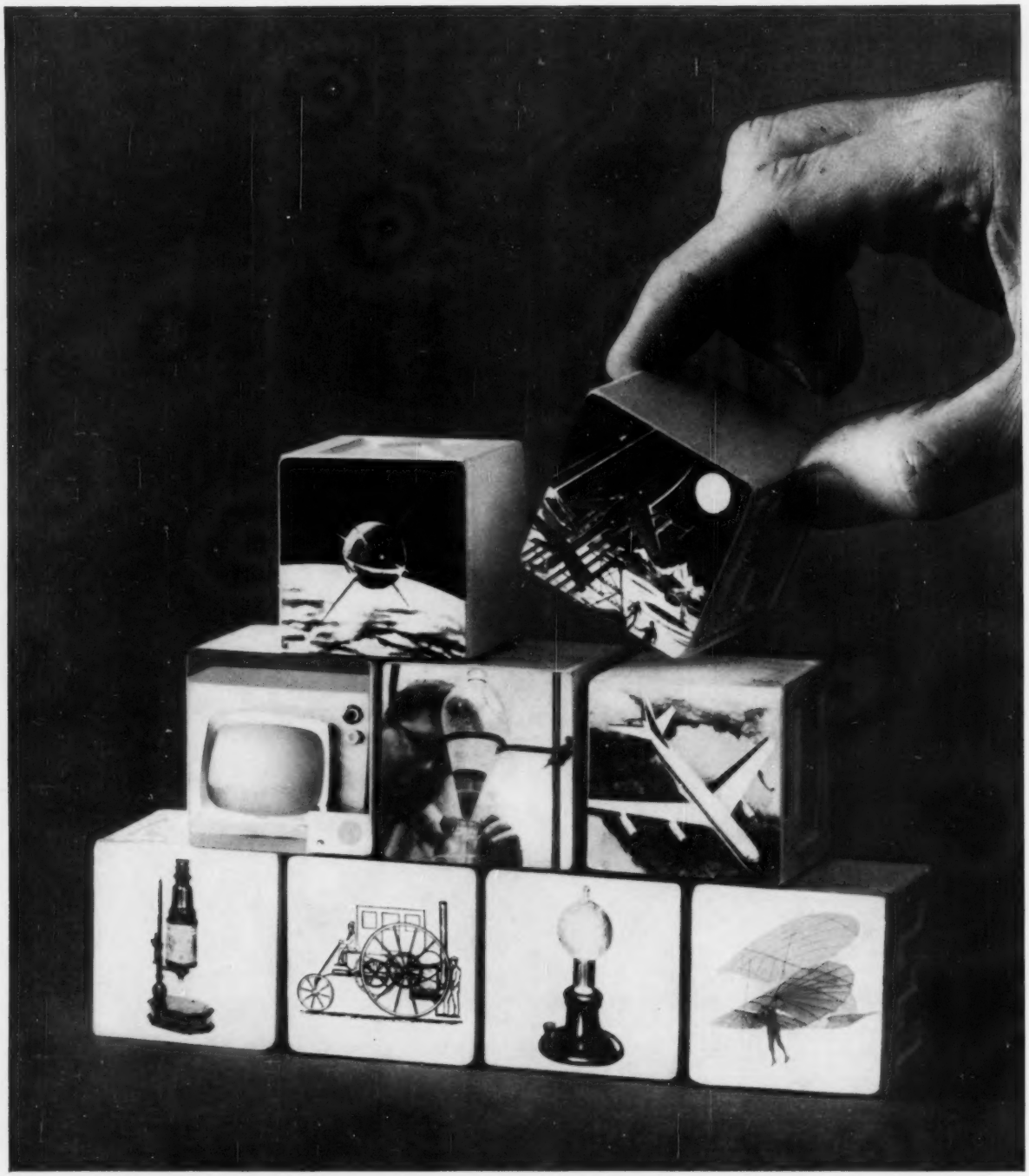
If you are designing, building or operating heat exchangers, it will pay you to discuss trouble-free performance with Scovill.

HEAT EXCHANGER TUBE for Applications from Marine to Petrochemical, from Compressor Intercoolers to "Cat-Cracker" Exchangers, in these popular Alloys . . .
Phosphorized Admiralty • Admiralty • Arsenical Admiralty • Red Brass, 85% • Deoxidized Copper • Arsenical Copper • Cupro-Nickel 10%-20%-30% • Aluminum Brass • Aluminum Bronze, 5% • Muntz Metal • Duplex Tube

MADE IN U.S.A. TO THE STANDARDS OF AMERICAN INDUSTRY

Scovill Manufacturing Company, Mill Products Division, 99 Mill Street, Waterbury 20, Connecticut. Phone Plaza 4-1171.

SSC18



"It is important to note that the unfolding possibilities of science and technology are likely to be realized at an even greater pace in the future. For discovery and invention feed on themselves. With every new discovery and invention we broaden the base upon which others are built."

— M. J. Rathbone, President

ESSO

Standard Oil Company (New Jersey)

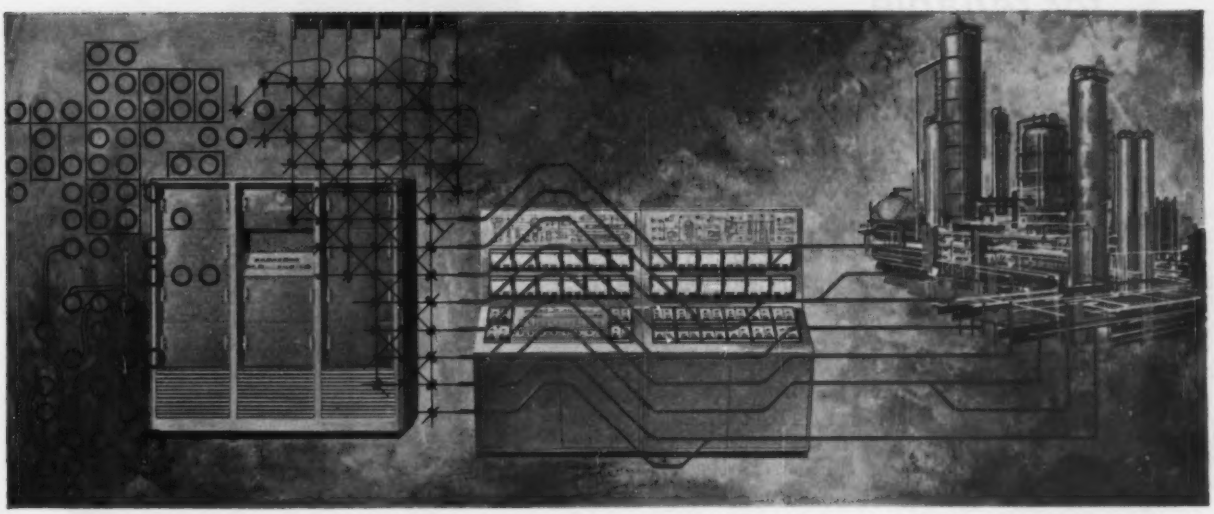
For more data on advertised products, use Readers' Service Cards, last page.

the instruments

the computer

the systems engineering...

now Foxboro brings you all three



A dynamic new force in computing control is now available to the process industries. Foxboro, and the Radio Corporation of America, contributing their individual capabilities, bring industry its first completely integrated computing control system. From Foxboro, the instrumentation, the knowledge of process dynamics. From RCA, the digital computer, and its special electronic techniques. A breadth and depth of talent available with overall systems responsibility through The Foxboro Company. When you are investigating the feasibility of computing control, look into this new force. The Foxboro Company, 744 Neponset Avenue, Foxboro, Massachusetts, U. S. A.

FOXBORO

REG. U.S. PAT. OFF.

For more data on advertised products, use Readers' Service Cards, last page.

Just add water...

for reliable, low-cost high temperature protection

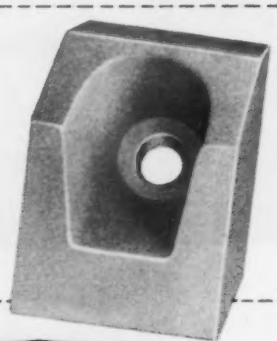
With Norton ALUNDUM* Castables it's practically that simple and economical to make refractory shapes that would otherwise cost you far more. You make your own molds and, following a few simple directions, mix and pour your own furnace arches, domes, covers, spouts for melting furnaces, etc. Even the most complex shapes can be formed easily and inexpensively. And ALUNDUM Castables are ideal for furnace conditions in all types of atmospheres at temperatures up to 3,300°F.

This versatile castable is available in two types: 1. ALUNDUM 33-I Castable, made up principally of pure fused aluminum oxide *bubbles*. Its light weight and high insulating properties suit it for use in furnace applications subject to high temperature radiation, but mild gas and flame erosion. It is often used as a back-up for ALUNDUM 33-HD material in linings and roof arches. 2. ALUNDUM 33-HD Castable, made up principally of dense, fused *grains* of pure aluminum oxide. It is ideally suited for forming dense, monolithic surfaces where conditions are more severe — provides positive protection against flame impingement and abrasion.

Cut down time for repairs, your inventory of required shapes . . . and save with Norton ALUNDUM Castables. Write for new catalog with complete characteristics and casting instructions. NORTON COMPANY, **463** New Bond Street, Worcester 6, Massachusetts.

*Trade-Mark Reg. U. S. Pat. Off. and foreign countries

Imagine the savings in making complex shapes like this tapping block right *in your plant.*



NORTON
REFRACTORIES
Engineered... Rx ...Prescribed

75 years of . . . **Making better products . . . to make your products better**

NORTON PRODUCTS: Abrasives • Grinding Wheels • Machine Tools • Refractories • Electro-Chemicals — **BEHR-MANNING DIVISION:** Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

Make pre-formed shapes and liners with

DFC castable refractories

They are castable! Install DFC castable refractories without reinforcing. Installed with DFC anchors, they form concrete-like structural strength in a few hours after placing, with normal air drying. Difficult wall sections or other linings poured or gunned quickly and economically, no waiting for high cost special shapes! There is a DFC castable exactly right for *your* refinery furnaces.

DFC HI-CAST—For making complete monolithic linings, arches, patches, etc., in boiler settings and nearly every type of furnace. Replaces standard and special shape fire brick—and it is fully prepared. Mix with water and install!

Hi-Cast No. 24
(Temp. Range: Atmospheric to 2400°F.)
This low or moderate temperature type is used where service temperatures do not exceed 2400°F. Used for many heating boilers and furnaces, door linings, furnace floors, ash pits, flues, ducts, etc.

Hi-Cast No. 28
(Temp. Range: 1800°F.-2800°F.)
For high-temperature service. Suitable for temperatures up to 2800°F.

Hi-Cast No. 30
(Temp. Range: 2000°F.-3000°F.)
An especially refractory type, equal to the best grade of fire clay brick, to use at very high temperatures.

Serving Industry with Fine Refractories Since 1876

Denver Fire Clay Company
3033 Blake Street—Denver 17, Colorado
DENVER • SALT LAKE CITY • NEW YORK

Super Hi-Cast (P.C.E. 34)
High-temperature castable refractory for use at elevated temperatures beyond the limits of ordinary castable refractories. Ideal for burner cones, door linings, walls, roofs, arches and other applications where mix may be poured into forms.

CELLO-CAST—Combination refractory and insulating material, widely adaptable in replacing insulating brick and tile. Cello-Cast has low thermal conductivity and low heat storage. Apply in heating furnaces, boilers, and industrial furnaces not subjected to slag attack or mechanical wear.

Cello-Cast No. 20
Temp. Range Atmospheric to 2000°F.

Cello-Cast No. 24
Temp. Range Atmospheric to 2400°F.

HI-CAST AR—A very high strength, abrasion resistant refractory. Useable for service temperatures not exceeding 2750°F.

THE DENVER FIRE CLAY COMPANY
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Please send further information on DFC Castable Refractories. DFO-6

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Company:.....

Address:.....

City and State:.....

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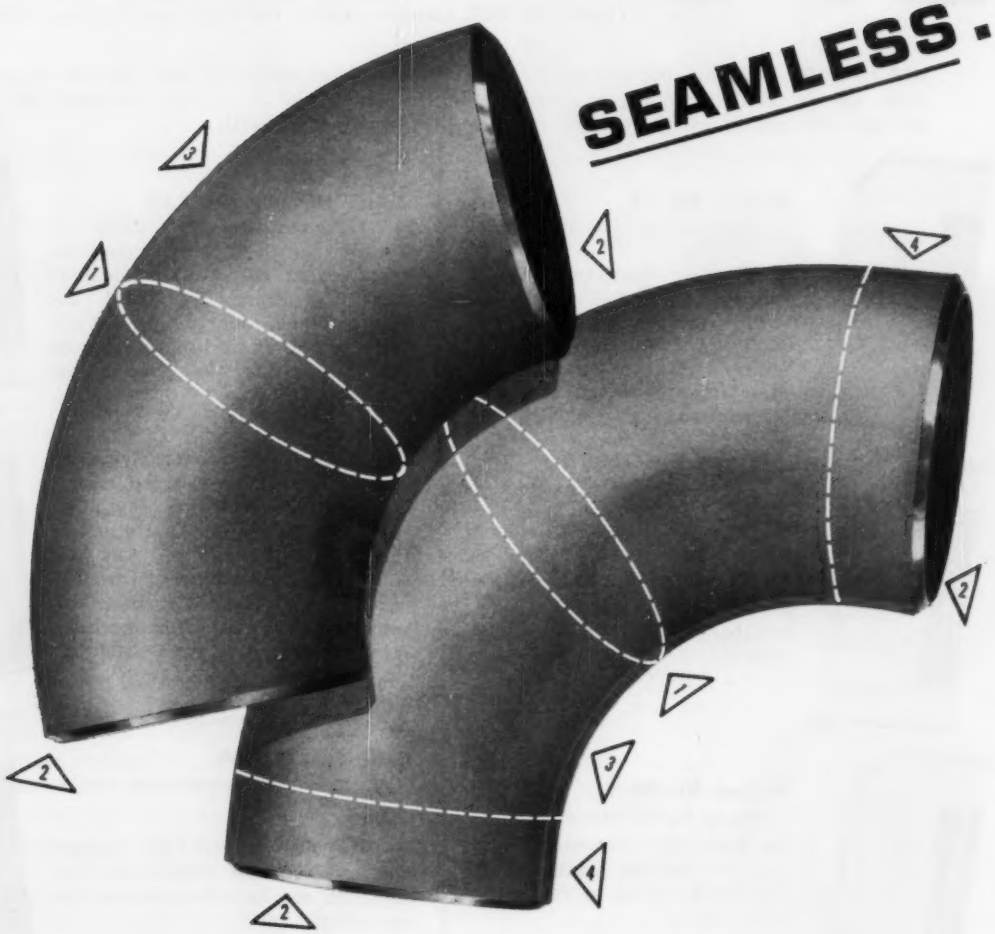
NOW...BOTH!

SEAMLESS.



1. BONUS... All fittings hot-coined in compression throughout entire length—dimensionally true to permit segmenting at any point. **2.** BONUS ... Seamless and welded-type fittings with specially machined ends assure uniform thickness and diameters . . . ends that are circle-perfect, plumb and square. **3.** BONUS... Wall thickness and uniformity—greater than required by ASA Standards. **4.** BONUS... Long Tangent bonus on welded-type fittings—NO EXTRA COST—saves pipe, simplifies lining-up, eliminates short welded stubs.

5951

..BY MIDWEST

NEW! The finest *seamless* welding fittings ever made. NOW—a hot-coined fitting, dimensionally accurate from end to end . . . fittings forged at controlled heat for superior metallurgical quality . . . with specially machined ends for quickest fit-up and welding! Produced by the newest and most modern equipment—combined with the latest technology in forging, sizing, heat-treating, and machining. Available in all sizes through 24″—long radius or short—90's, 45's, 180's.

WELDED . . . BY MIDWEST

Welded-type fittings, fully reinforced . . . especially "Long Tangent" bonus fittings . . . always available from stock in carbon steel through 36″ (to order through 48″)—same high quality as always. Also available from stock in wrought iron and chrome-moly. Fittings formed from plate and welded are ideally suited to unusual requirements—heavy wall (2″, 3″, 4″ or more) . . . Hi-Yield, Inconel, stainless, Hastelloy and all other weldable metals. Extra tangent lengths, reducing ells, and special fittings of all kinds are made best as welded-type fittings.

THE WORLD'S MOST COMPLETE LINE OF WELDING FITTINGS . . . sold through stocking distributors from coast to coast.

MIDWEST

Write for NEW brochure
SEAMLESS AND WELDED-TYPE
FITTINGS, No. 60-C

PIPING COMPANY, INC.
1450 South Second Street *St. Louis 4, Missouri*

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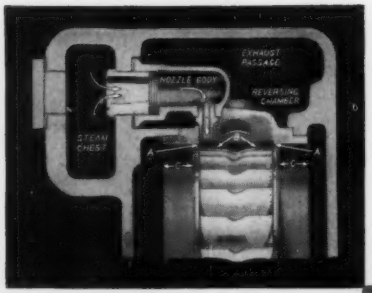
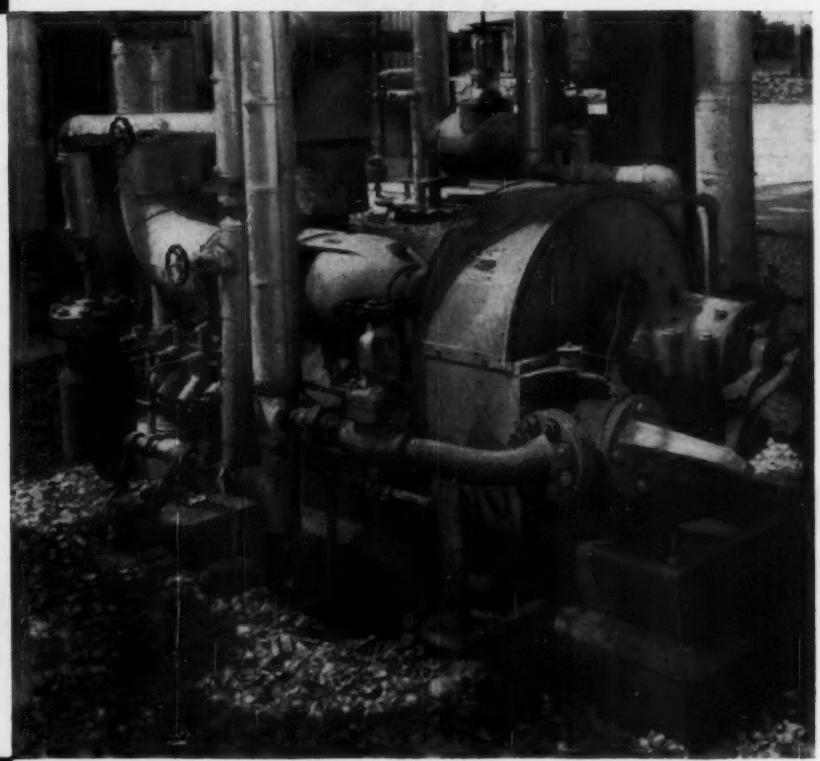


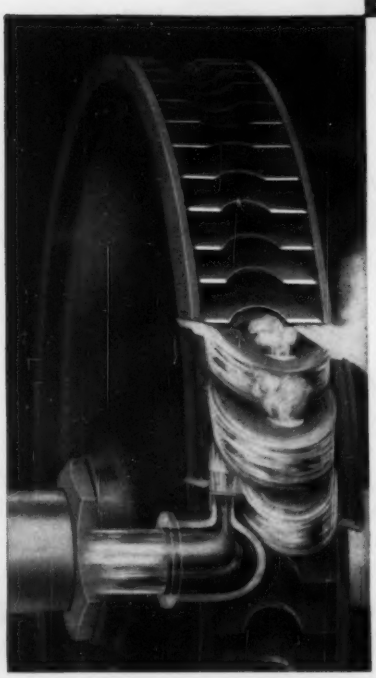
TWO REASONS WHY

this turbine seldom sees down time

1 ***Generous wheel clearances:*** AA —rim clearance, B—blade clearance, CC —side clearance. Blades can't foul as they are protected by rims. Rubbing at AA will do no damage. Side clearance is so large (about one inch) that end-play from excessive external thrust cannot damage wheel.



2 ***Blade wear is of little consequence.*** In a Terry solid-wheel turbine, the steam enters the buckets at right angles to the shaft. As its power-producing action takes place on the curved surfaces at the backs of the buckets, wear does not materially affect horsepower or efficiency.



To prevent costly shutdowns for repairs, Terry builds bonus reliability into each solid-wheel turbine. Two of the ways in which this is accomplished are shown in the diagrams at the left.

Further details of these simple, fool-proof turbines are illustrated and described in bulletin S-116. If you do not already have a copy of this publication, send for one today. No cost or obligation.

THE TERRY STEAM TURBINE CO.
TERRY SQUARE, HARTFORD 1, CONN.

TT-1217

TERRY

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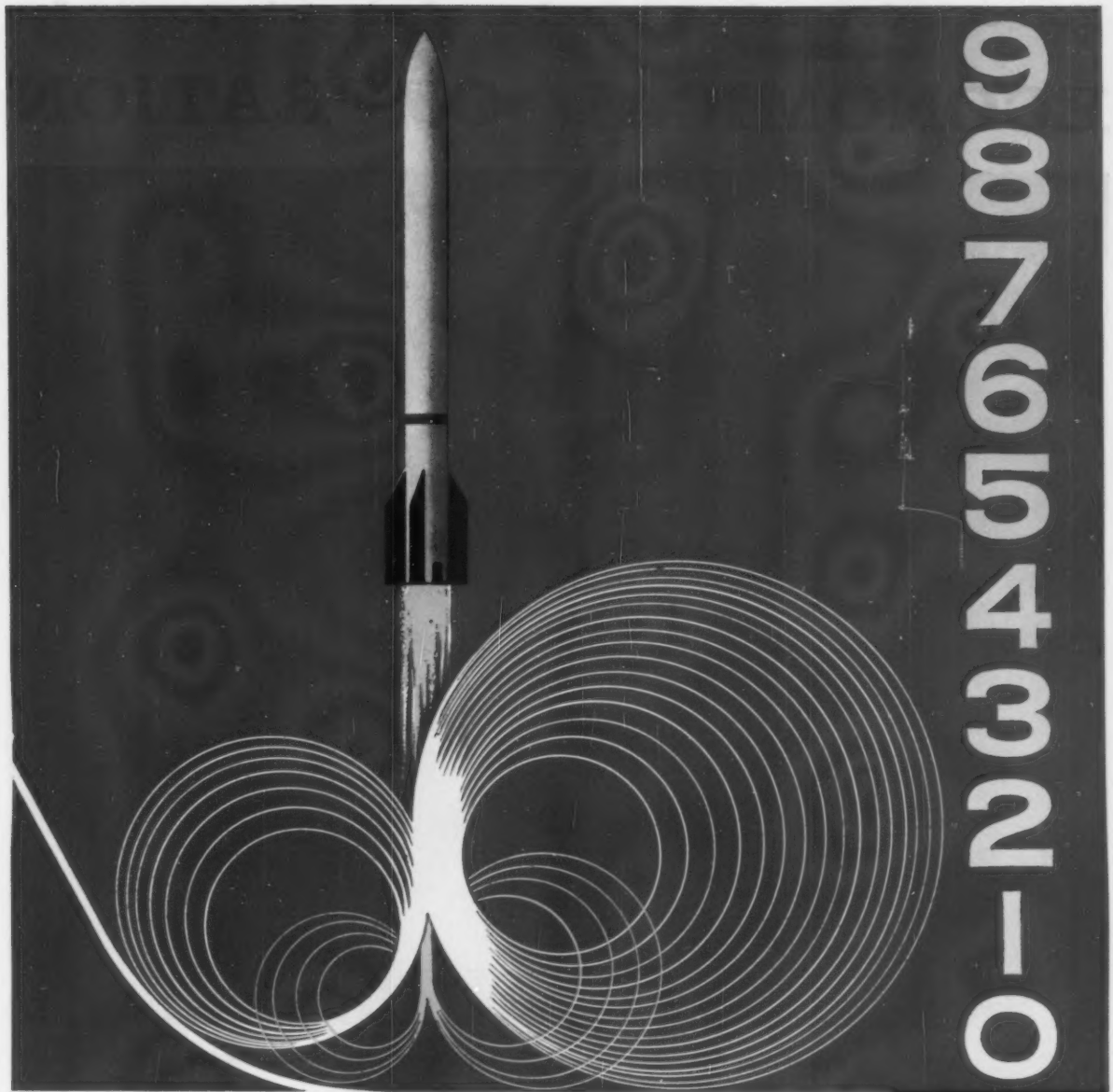

hot countdown . . . cool blastoff

sophisticated piping systems use BONNEY SWEEPOLETS for branch connections

Bonney Sweepolets are in use on the Saturn missile launching pad on the high velocity water cooling system of the blast deflector. The long sweep of the Sweepolet provides maximum fluid flow and its sophisticated design provides optimum stress distribution. For all piping systems involving unusual or complex stresses at branch connections, you will be wise to specify Bonney Sweepolets. Write for catalog S-1A.

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also exclusive manufacturers of
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THREDOLETS®
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CARBON STEEL
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for all services

BONNEY FORGE AND TOOL WORKS, ALLENTOWN, PENNSYLVANIA

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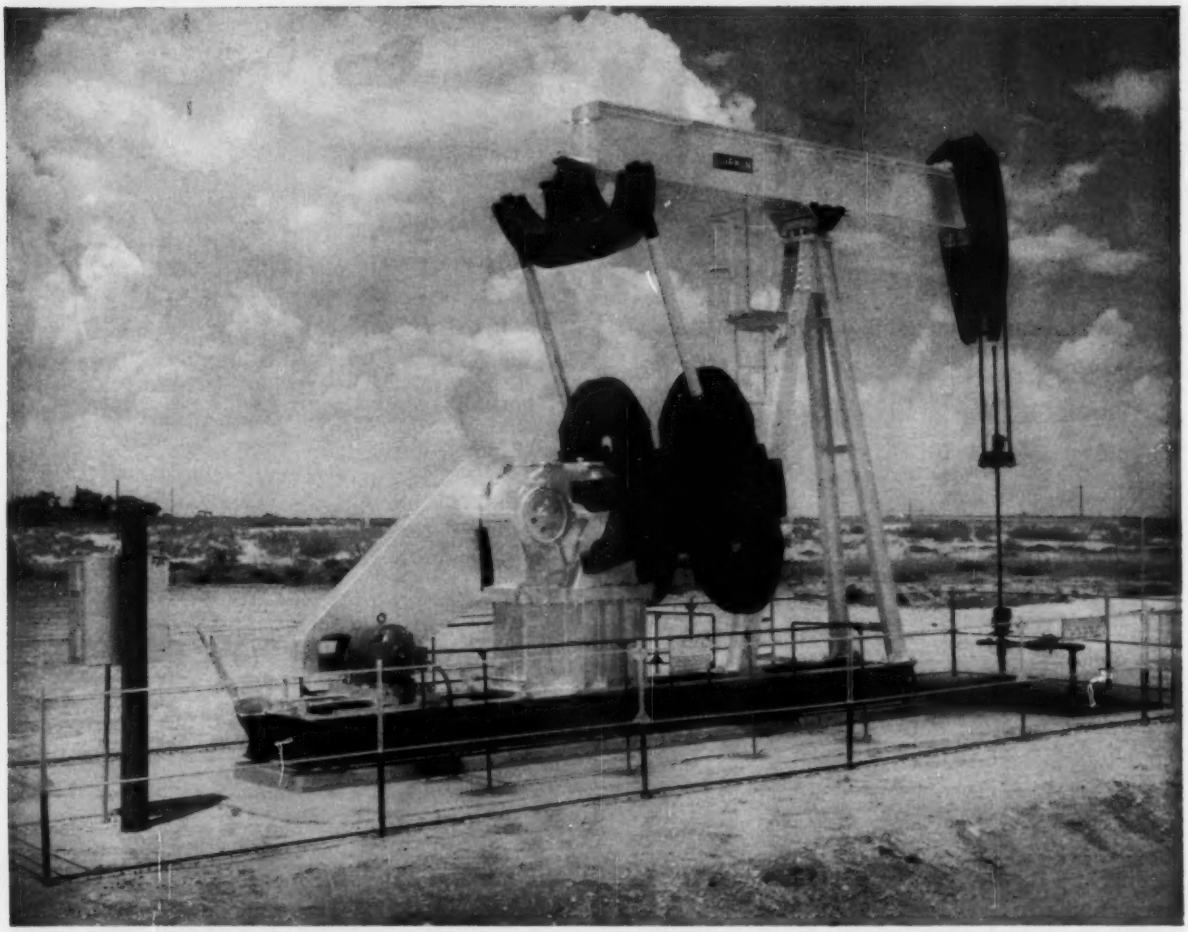
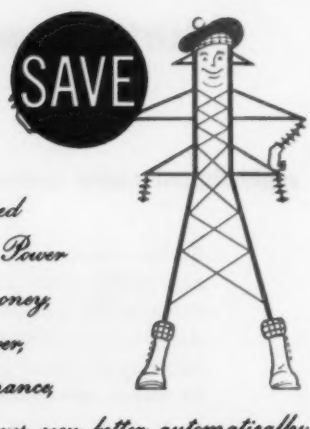
You can depend on purchased electric power for

ECONOMICAL OPERATION



Producing well in West Texas using low cost purchased power and automatic control

Producing fields that use utility electric power give the utmost in operating economy . . . this is one of the thousands of wells producing as required with lowest possible operating cost. If you want more from your production, gathering, pipelines or refineries . . . use and *depend* on purchased electric power. Call your nearest utility electric power company for details.



Purchased Electric Power saves money, manpower, maintenance, and serves you better automatically

Petroleum Electric Power Association

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POWELL
PETROLEUM PROCESSING
VALVES

Performance makes the world of difference

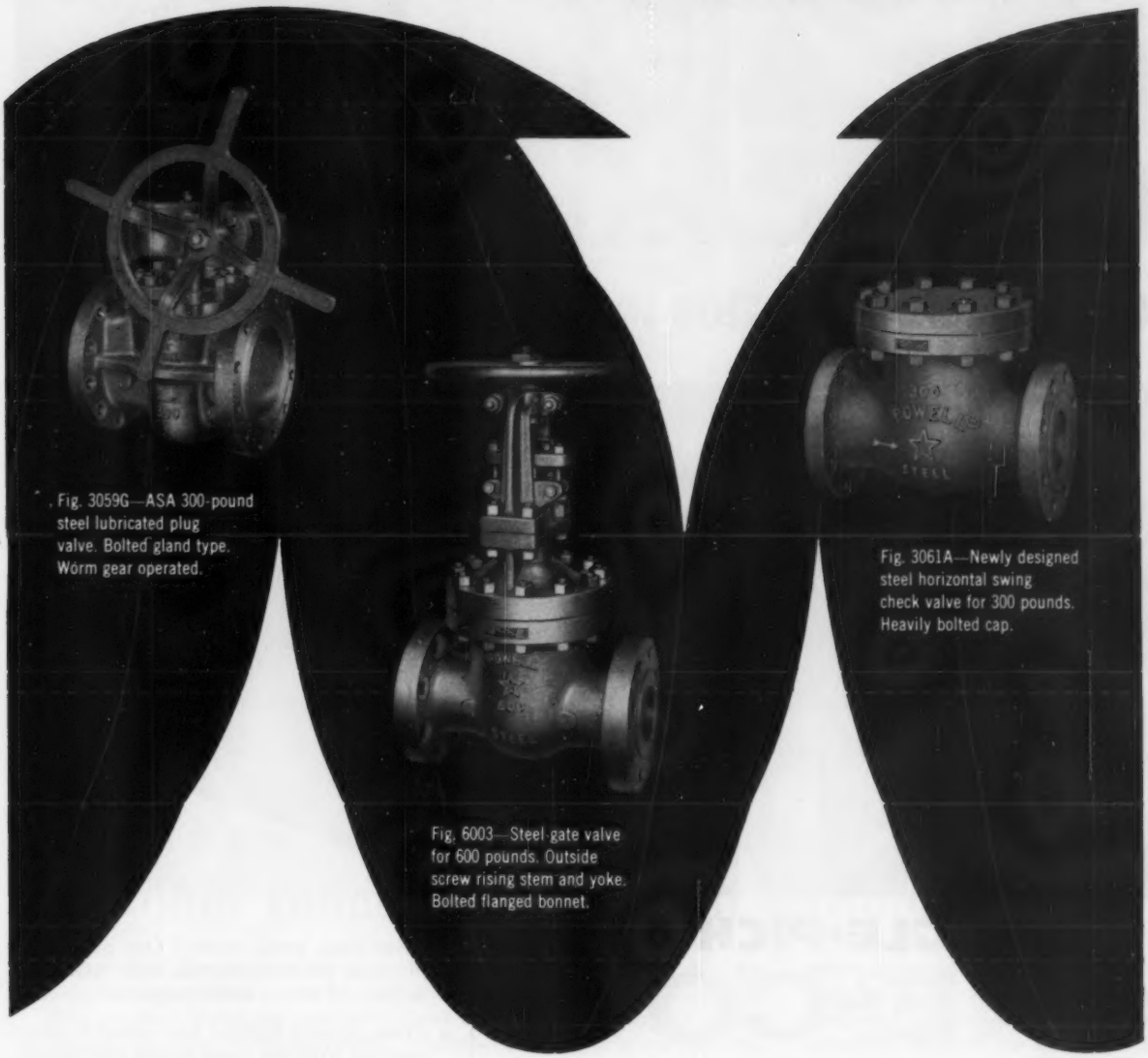

Fig. 3059G—ASA 300-pound steel lubricated plug valve. Bolted gland type. Worm gear operated.

Fig. 6003—Steel gate valve for 600 pounds. Outside screw rising stem and yoke. Bolted flanged bonnet.

Fig. 3061A—Newly designed steel horizontal swing check valve for 300 pounds. Heavily bolted cap.

Powell steel valves have been performance proven for more than a century in controlling the flow of fluids in refineries, petrochemical plants and storage facilities.

Also, there are Powell Valves in bronze, iron, pure metals and special alloys for handling water, oil, gas, air, steam and corrosive media. So whatever your flow control need may be, you can depend upon a Powell Valve to take care of it.

Contact your nearest Powell Valve distributor or write directly to us. Our experienced engineers will help you to satisfactorily solve any of your valve problems.

Powell . . . world's largest family of valves

THE WM. POWELL COMPANY • DEPENDABLE VALVES SINCE 1846 • CINCINNATI 22, OHIO

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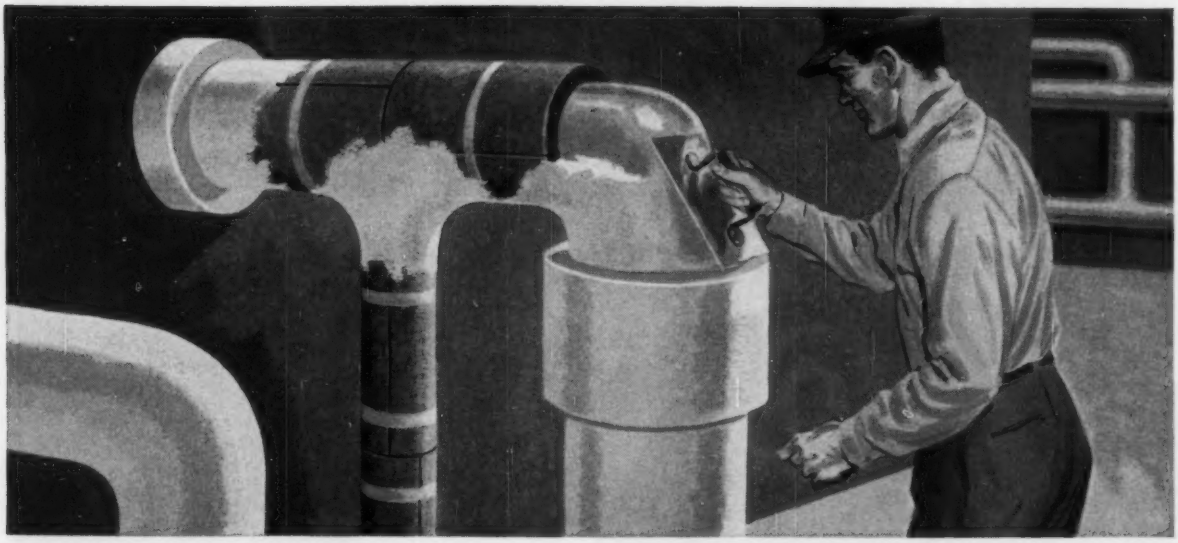
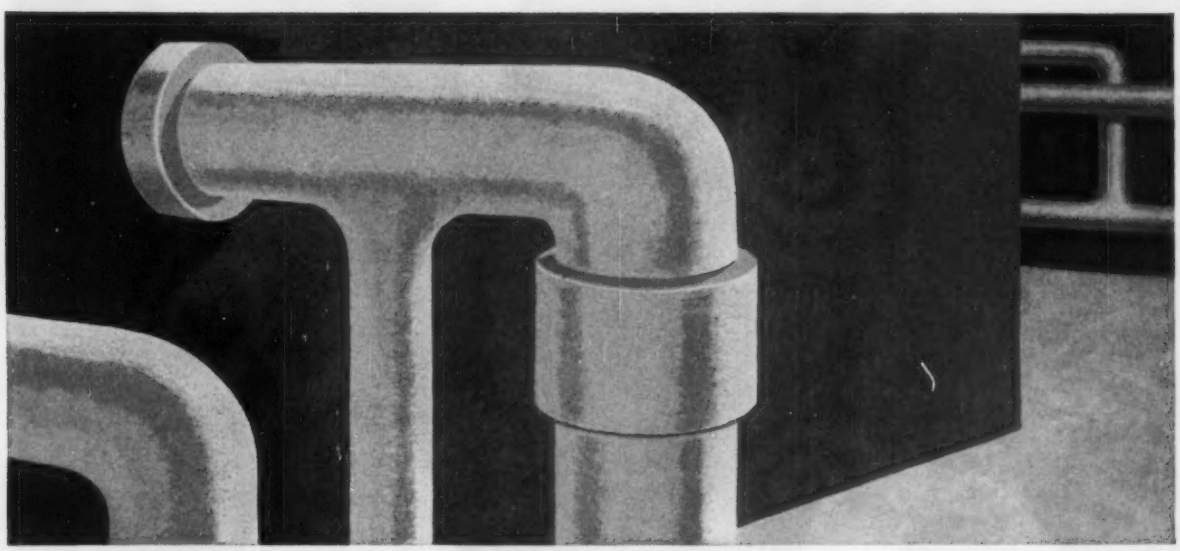


ONE QUICK APPLICATION INSULATES, PROTECTS, FINISHES!



EAGLE-PICHER
ONE-COTE CEMENT

Eagle-Picher produces a complete line of industrial insulations for all temperatures from below Zero to over 2000 F.

EAGLE EP PICHER

Since 1843

The Eagle-Picher Company

Dept. PR-4, Cincinnati 1, Ohio

(Member National Insulation Manufacturers Ass'n)

- Saves time, work, money! One quick application provides smooth, light reflectant surface on hot or cold equipment!
- Clean, easy to handle! Just trowel it on—even on irregular areas where application of other insulations is often impractical.
- Highly efficient! Effective insulation at temperatures up to 1000 F.
- For outdoor installations! Quick-setting, withstands rain and moisture two hours after application. Prevents rust!
- For indoor installations! Requires no wire mesh or finishing treatment!

Quick dissolving and free flowing, Du Pont improved flaked petroleum dyes take approximately half the space of the powdered form.

Free flowing Du Pont *flaked* dyes offer refineries important advantages

Du Pont offers oil colors either in powder or flaked form.

Since Du Pont flaked dyes are virtually dust free, they have been gaining steadily in popularity. And now the newest flaked dyes from Du Pont are further improved; they dissolve more readily than ever.

Less bulk. You'll find that the flaked Du Pont Petroleum Dyes take approximately half the space of the same dye in powdered form, thus saving valuable storage space. Flaked dyes are shipped in easily handled small drums.

Wide color range. You can get Du Pont flaked dyes in orange, red and bronze. Blue is supplied in a crystalline form offering approximately the same advantages as you get when you use Du Pont flaked dyes.

More information. For more details and samples, contact your Du Pont Petroleum Chemicals representative. Or write to: E. I. du Pont de Nemours & Company (Inc.), Petroleum Chemicals Division, Wilmington 98, Delaware.

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Tetraethyl Lead
and other
Petroleum Additives

you can take full advantage of the fuel situation with

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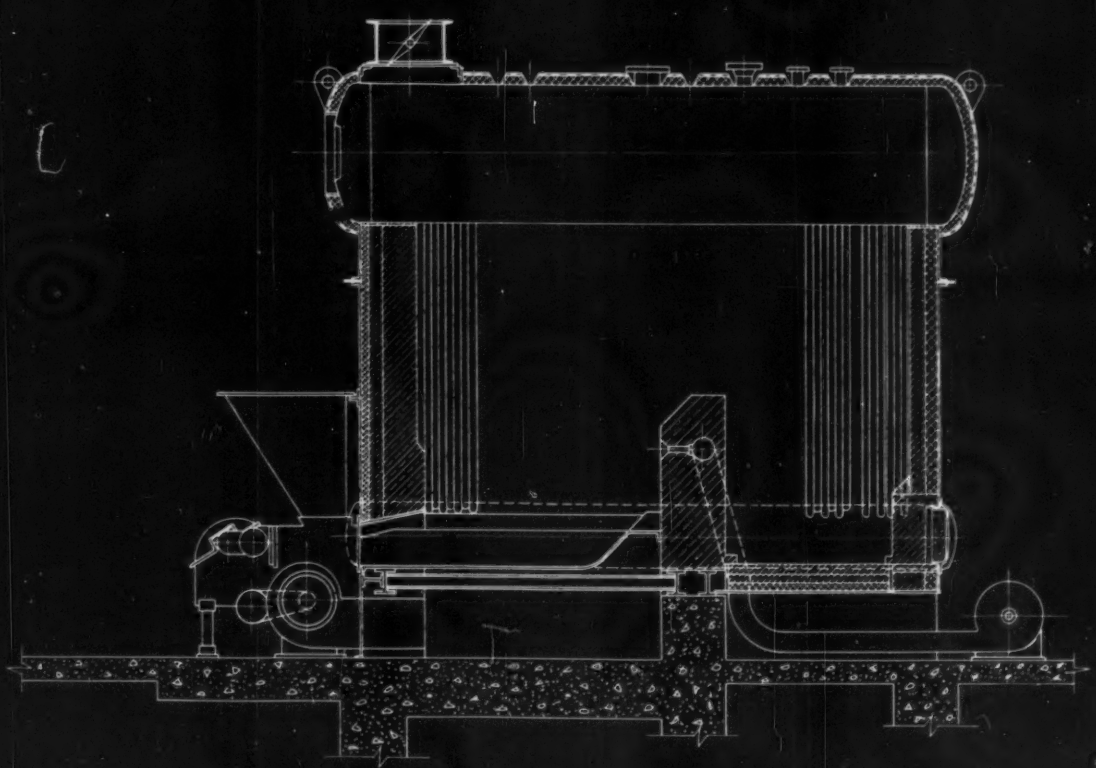
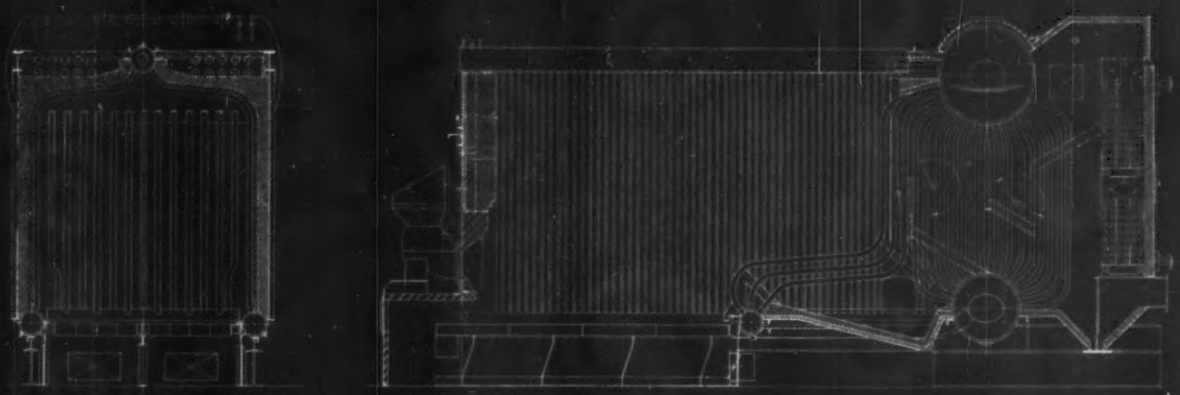
PACKAGE STOKER-FIRED STEAM GENERATORS

Designed and built to WICKES recognized standard of excellence, engineered to WICKES high standard of efficiency

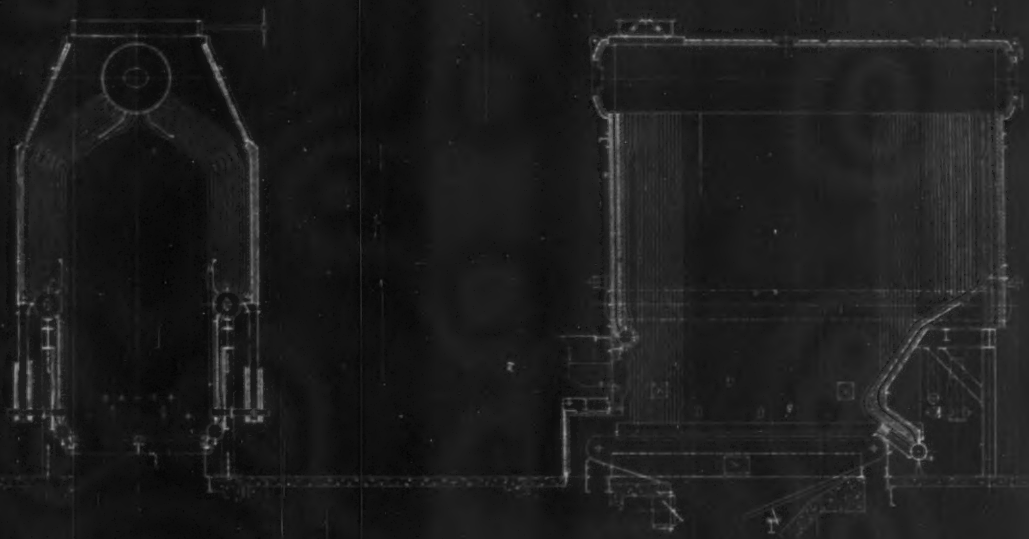
These stoker-fired WICKES generators are compact, package water tube boilers, custom-engineered to your exact steam generating requirements. Semi-automatic in operation and convertible from stoker-fired to either gas or oil fired, these WICKES generators are built to the highest standards of workmanship to give you the same efficiency of operation that you have come to expect from all WICKES-built boilers. They are built in a variety of designs to meet size, space and fuel conditions. For complete information on these WICKES stoker-fired units as well as the complete line of WICKES water tube steam generators, ask the WICKES sales representative nearest you to call . . . offices in principal cities*.



TYPE A



TYPE S-3



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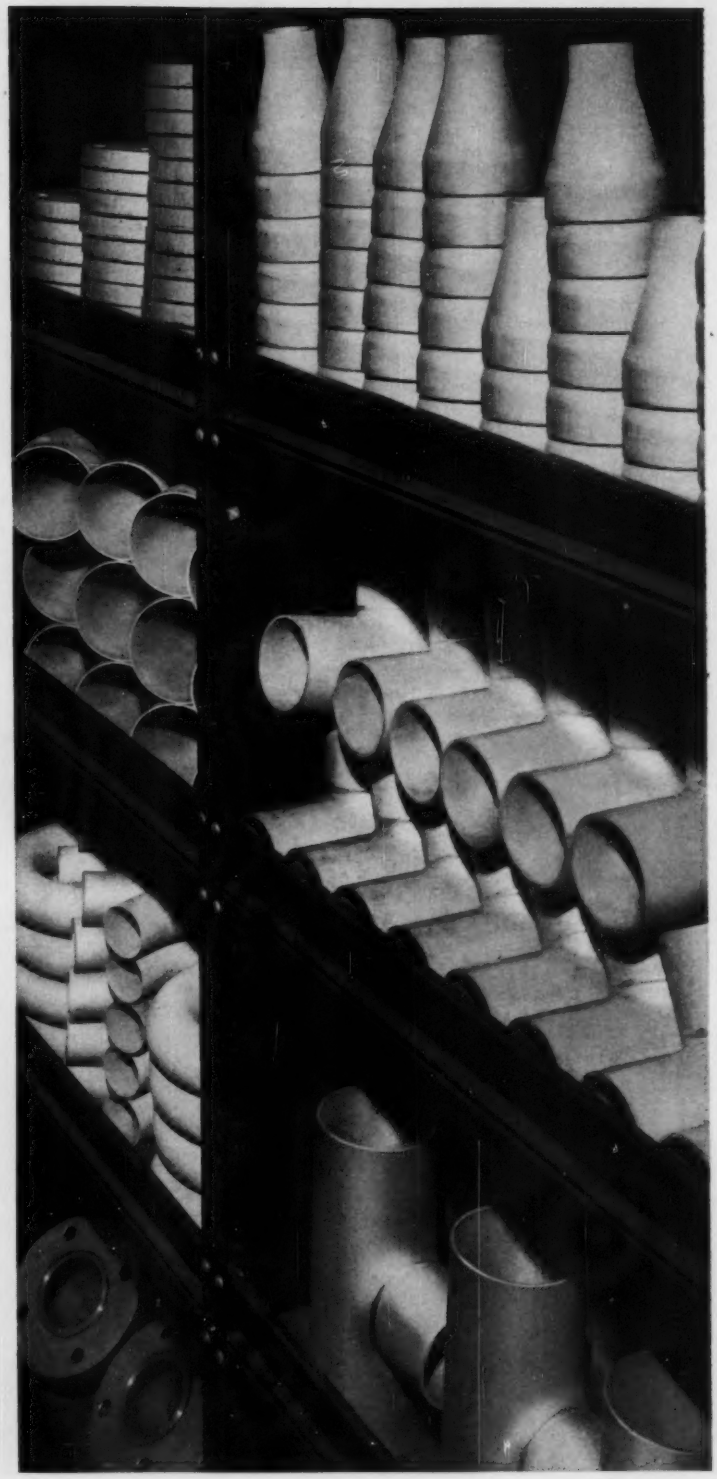
FITTINGS ARE IN STOCK NOW... COAST TO COAST

It's one thing to catalog a complete line of long-tangent fittings . . . it's another to have them ready to ship to your plant—*when* you need them. Speedline engineering and manufacturing experience has "standardized" production on even the most specialized fittings . . . including eccentric reducers, reducing tees and crosses . . . making it possible to maintain extensive inventories both at the factory *and* in the field.

A Speedline distributor is prepared to give delivery-from-stock on stainless steel fittings . . . including Carpenter 20 . . . for every process piping requirement. He can also assure prompt service on Speedline fittings in aluminum, titanium, zirconium, Hastelloy and other special corrosion-resistant alloys.

Leading plants have proved there *is* a measurable difference with Speedline fittings . . . the only complete line of long-tangent fittings available from distributor stocks. Let a Speedline distributor prove the difference Speedline experience and ready availability can make at your plant.



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Speedline® **CORROSION-RESISTANT FITTINGS**

A PRODUCT OF **HORACE T. POTTS COMPANY** • 566 E. ERIE AVENUE, PHILADELPHIA 34, PA.

ETHANE RECOVERY IN YOUR FUTURE ?

better consult

with DELTA . . .

the engineering company with ethane experience behind it.

Although ethane recovery is still in its infancy, Delta Engineering Corporation has the design, engineering, and construction experience to produce a profit-making plant for you at minimum cost. The Hamilton and CVOC plants shown on this page are indicative of the creative thinking that goes into every performance-proved project engineered by Delta. Whether ethane recovery is in your future in the form of a new plant or as an addition to your present facilities, consult with Delta first—the engineering contractors with ethane experience behind them.

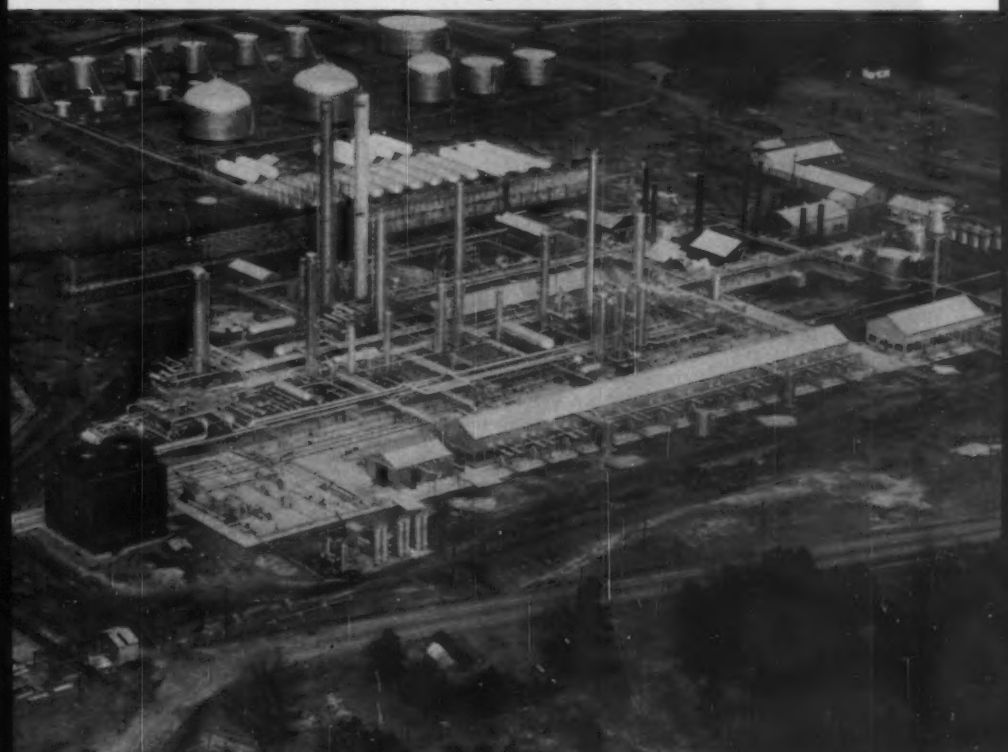
HAMILTON PLANT

Columbia, Ark. Constructed for Arkansas-Louisiana Chemical Corporation to process a maximum of 400 million cubic feet of gas per day and produce 85,000 gallons per day of ethane. Facilities are designed to double ethane production in the future.

Four 100 ft. inlet gas exchanger trains with absorbers.

5,000 h.p. steam turbine driven centrifugal propane refrigerant compressor installation.

Centralized control room—showing process controllers and alarm system annunciator panels.

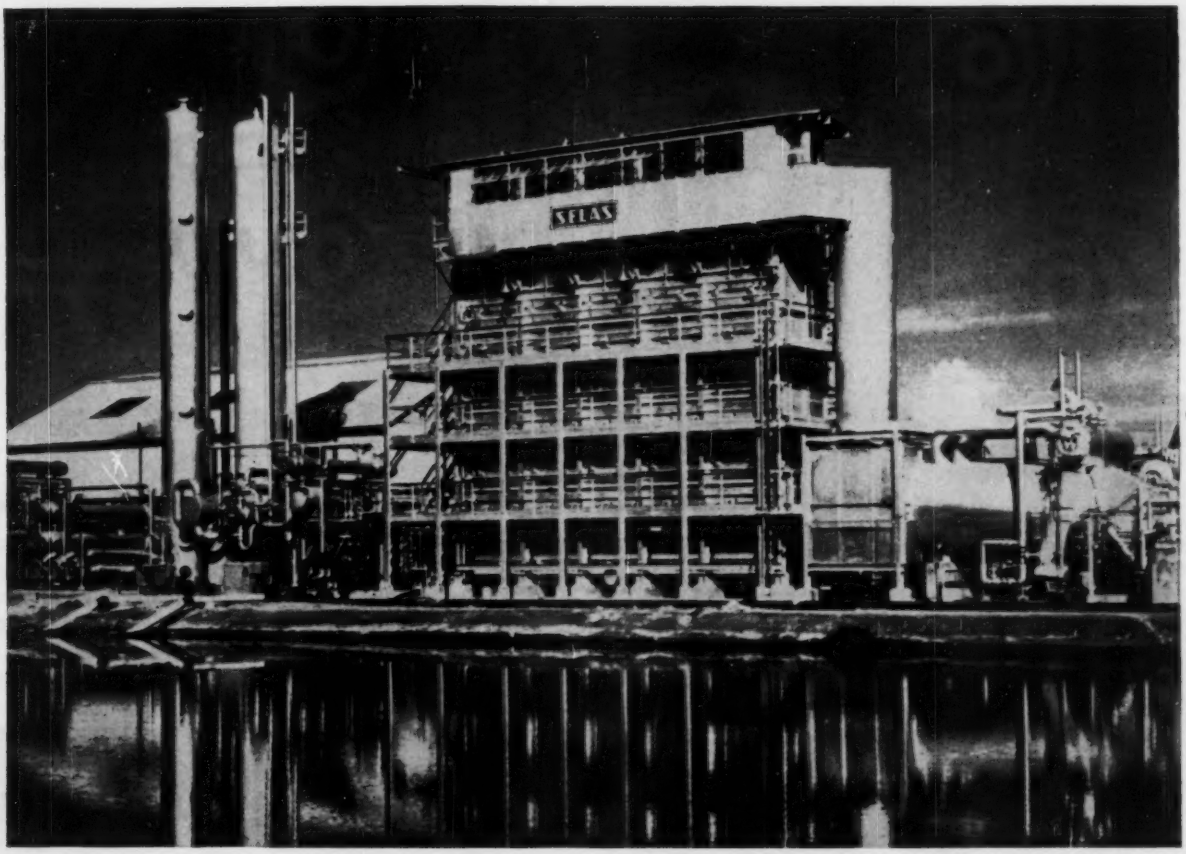


COTTON VALLEY OPERATORS COMMITTEE PLANT, WEBSTER PARISH, LA. This recycling plant was modified to process up to 240 million cubic feet of gas per day, and to recover 230,000 gallons of ethane per day. It utilizes a refrigerated, low molecular weight oil absorption process.

DELTA ENGINEERING CORPORATION

ENGINEERING CONTRACTORS

2121 SAN FELIPE ROAD • P. O. BOX 13256 • HOUSTON, TEXAS



California Ammonia Co. is owned in partnership by Best Fertilizer Co., Lathrop, Calif., and a group of farmers. Using Calamco ammonia, Best produces ammonium sulfate and over 20 different grades of pelleted ammonium phosphates and dry mixes.

CALAMCO Relies on Selas Gradiation® Heating to Meet Varying Hydrogen Production Demands

This new Selas steam-methane reforming furnace—installed at California Ammonia Co.'s Lathrop, California, anhydrous ammonia plant—provides the necessary versatility to meet a wide variety of production demands.

Controlled heat, delivered to the vertical tubes by Duradiant® burners positioned in rows along the furnace walls, assures:

- Preciseness of heating . . complete combustion within Duradiant burner cup permits placing burners close to tubes . . achieving fast heat-up and instantaneous response to controller demand.
- Heat uniformity . . even-heat distribution along and around tubes increases tube life by eliminating hot spots, minimizing coke formation.
- Versatility . . Duradiant burners, readily adjustable to desired heat pattern (in either horizontal or vertical rows), provide CALAMCO with an extremely versatile heat processing tool.

For example, the ability to alter burner pattern, enables CALAMCO to produce hydrogen under any of the following conditions:

- Boost throughput to meet increased production demands, without changing conversion.
- Increase conversion without changing throughput . . resulting in higher product yield.
- Operate for maximum thermal efficiency, at design throughput and conversion.
- Operate at lower tube wall temperature, at design throughput and conversion.

May we arrange for a Selas field engineer to discuss your heat processing needs with you? For this service—without cost or obligation to you—or for a copy of Bulletin "Gradiation Heating for Petroleum and Chemical Processing" write to Mr. M. R. Kitzen, chief process engineer, Fluid Processing Div., Selas Corporation of America, 74 Dreshertown Road, Dresher, Pa.

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Heat and Fluid Processing Engineers

DEVELOPMENT · DESIGN · CONSTRUCTION

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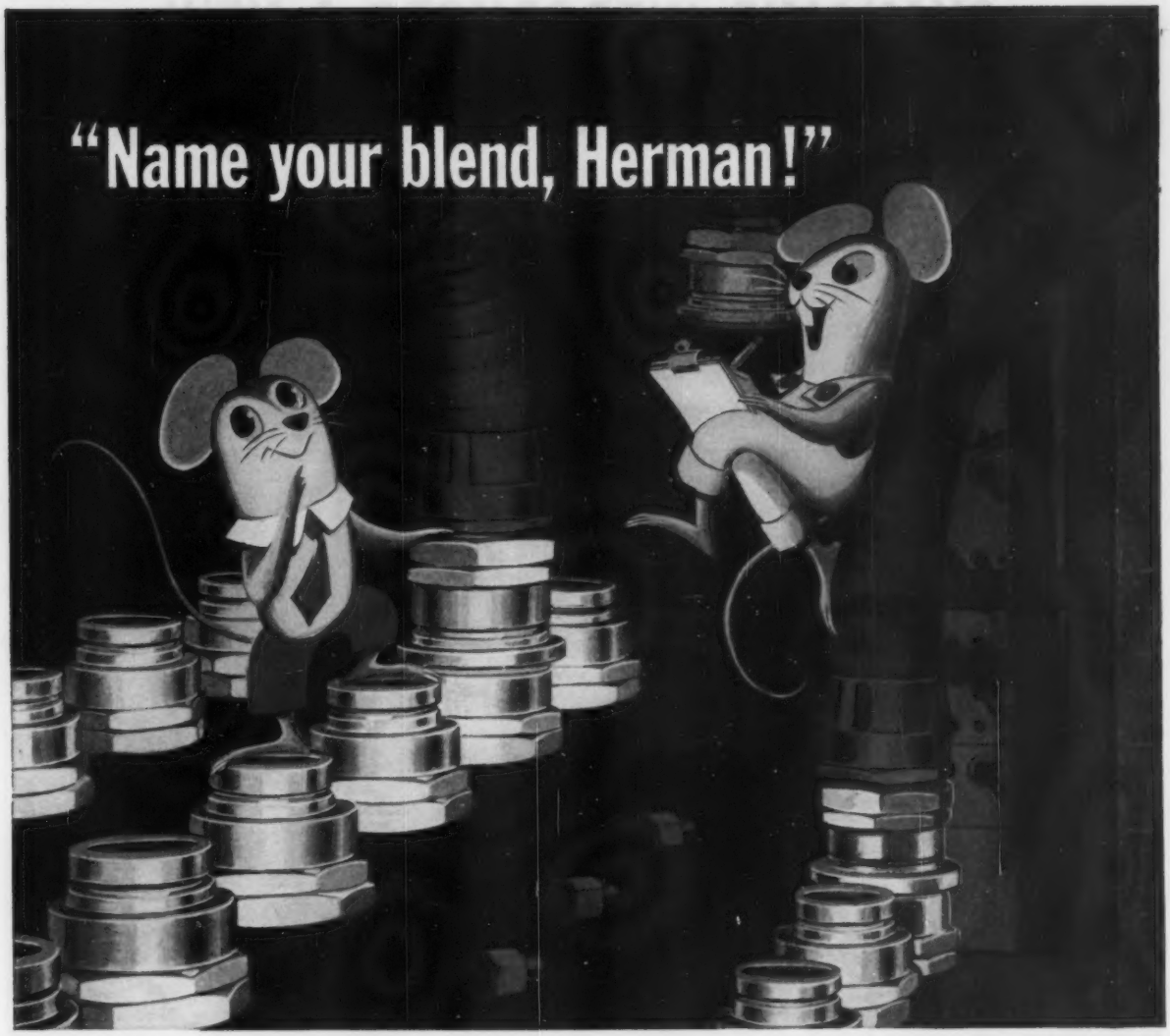


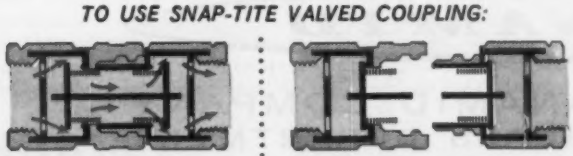
Here's the new, easy way to blend fluids: with Snap-Tite valved couplings on flexible lines

Now there's no need to laboriously open and close a lot of shut-off valves when you're blending petroleum products or other chemical fluids. With Snap-Tite valved couplings on flexible lines you can quickly switch hoses to any base stock line as required. Mixing is faster: you can perform more operations at one time . . . with no danger of contamination of base stocks by interflow through leaky valves! Valves with Snap-Tite couplings instantly shut off the flow when disconnected, and prevent run-out from overhead lines.

Under this arrangement, you store only base stocks to achieve infinite variations in blending. Not only do you save space, time and labor, but by eliminating shut-off valves and associated headers and permanent piping, you save substantially on equipment. In a recent installation (Standard Oil at Richmond, Cal.) the coupling cost was approximately one-third that of permanent piping!

For information, write for Snap-Tite Catalog No. 59. Ask for the name of your local Snap-Tite representative. There is no obligation.

TO USE SNAP-TITE VALVED COUPLING:



CONNECT—Full flow instantly

DISCONNECT—Stop flow instantly

☆ Snap-tite

ST-59-05

UNION CITY, PA.

CYANAMID INTRODUCES A NEW FLUID CRACKING CATALYST COMPOSITION—

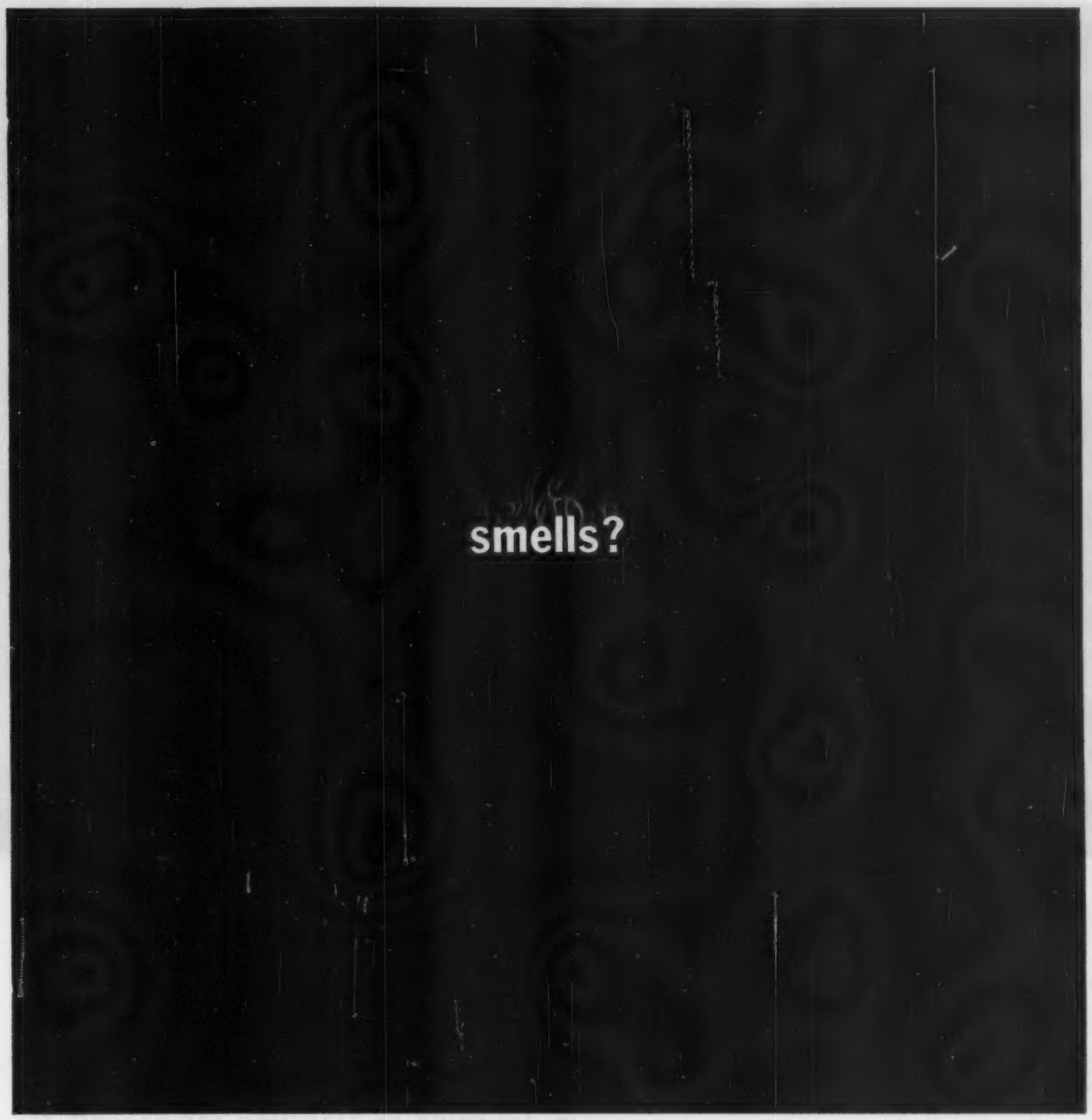
AEROCAT® 3C

Cyanamid, in cooperation with a major oil company, has developed AEROCAT® 3C—a new fluid cracking catalyst composition. Designed to provide refiners with more flexible and profitable refinery operations, AEROCAT 3C yields more gasoline, more propylenes and butylenes at the expense of dry gas and coke. AEROCAT 3C–12 for increased gasoline yield. AEROCAT 3C–20 for increased propylene and butylene yields.

BASIC IN CATALYST CHEMISTRY

CYANAMID

AMERICAN CYANAMID COMPANY
REFINERY CHEMICALS DEPARTMENT
30 Rockefeller Plaza, N. Y., 20, N. Y.



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Rhodia Inc. is the world leader in industrial odor control and reodorization technology and a primary producer of industrial aromatic chemicals. It offers fully qualified consultation service anywhere in the United States without cost or obligation.

Rhodia Alamask products are in use in virtually every industry to control malodor problems of stack gases, exhaust fumes, and plant effluvia effectively and economically. Rhodia "odor engineering" has also created greater market acceptability for wide range of finished products through the neutralization of unpleasant odors and/or the addition of pleasing and appropriate fragrances. Why not call or write Rhodia today about your problem, or use the coupon for additional information.

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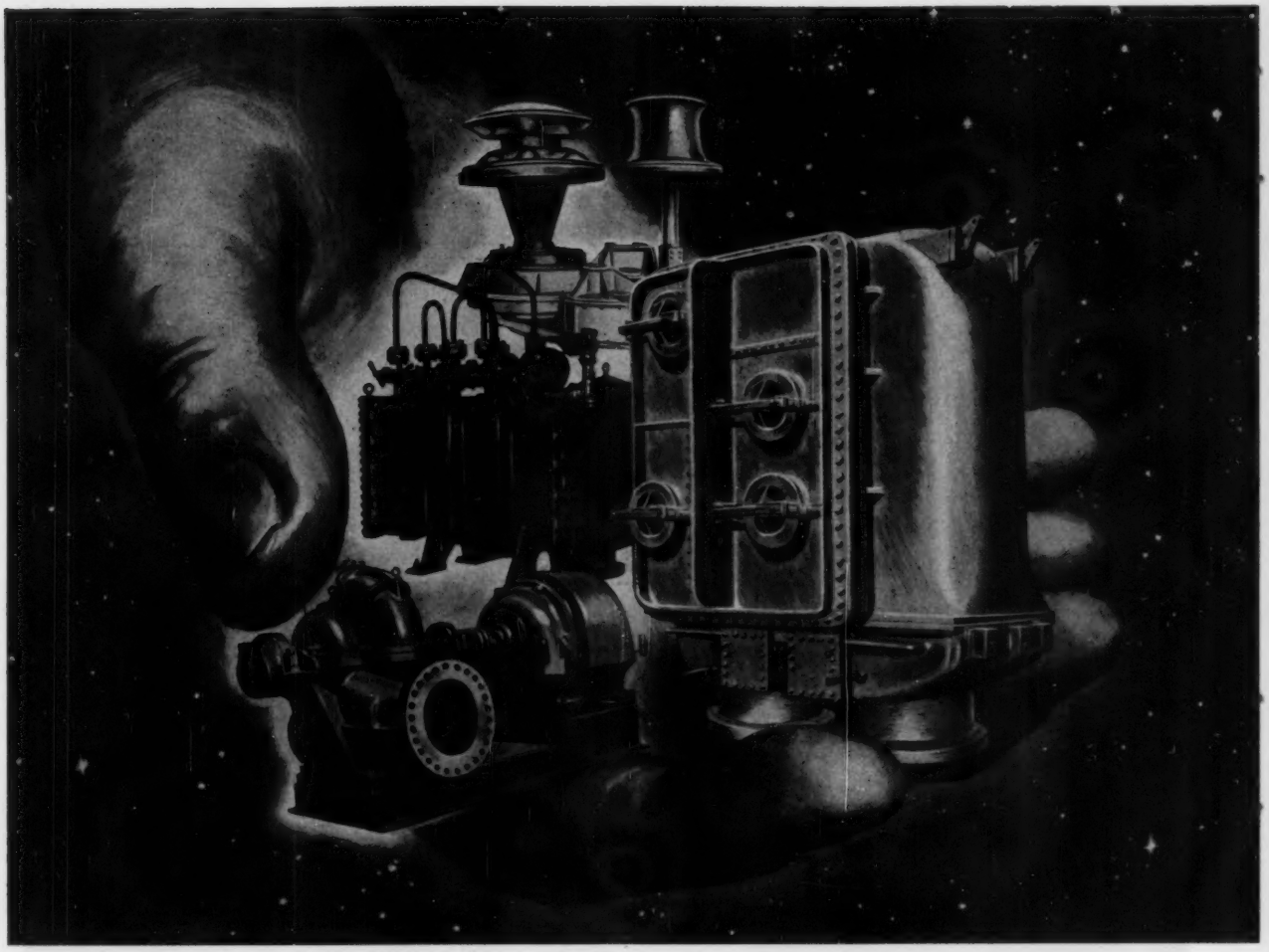

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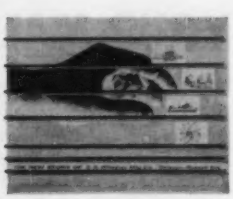

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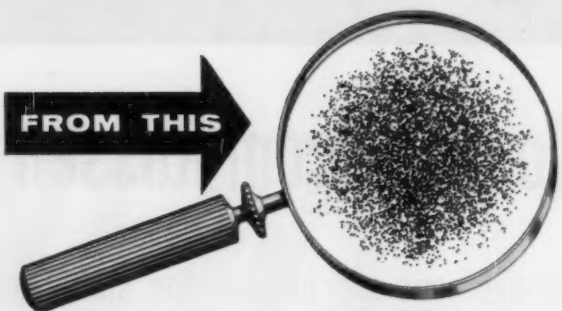

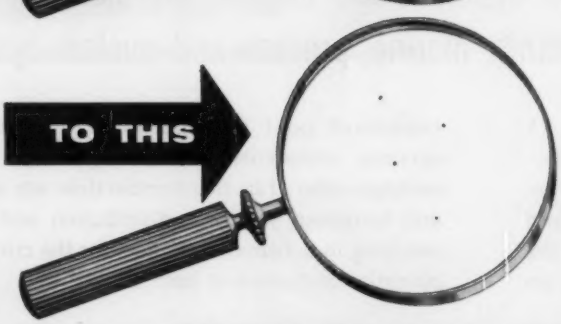

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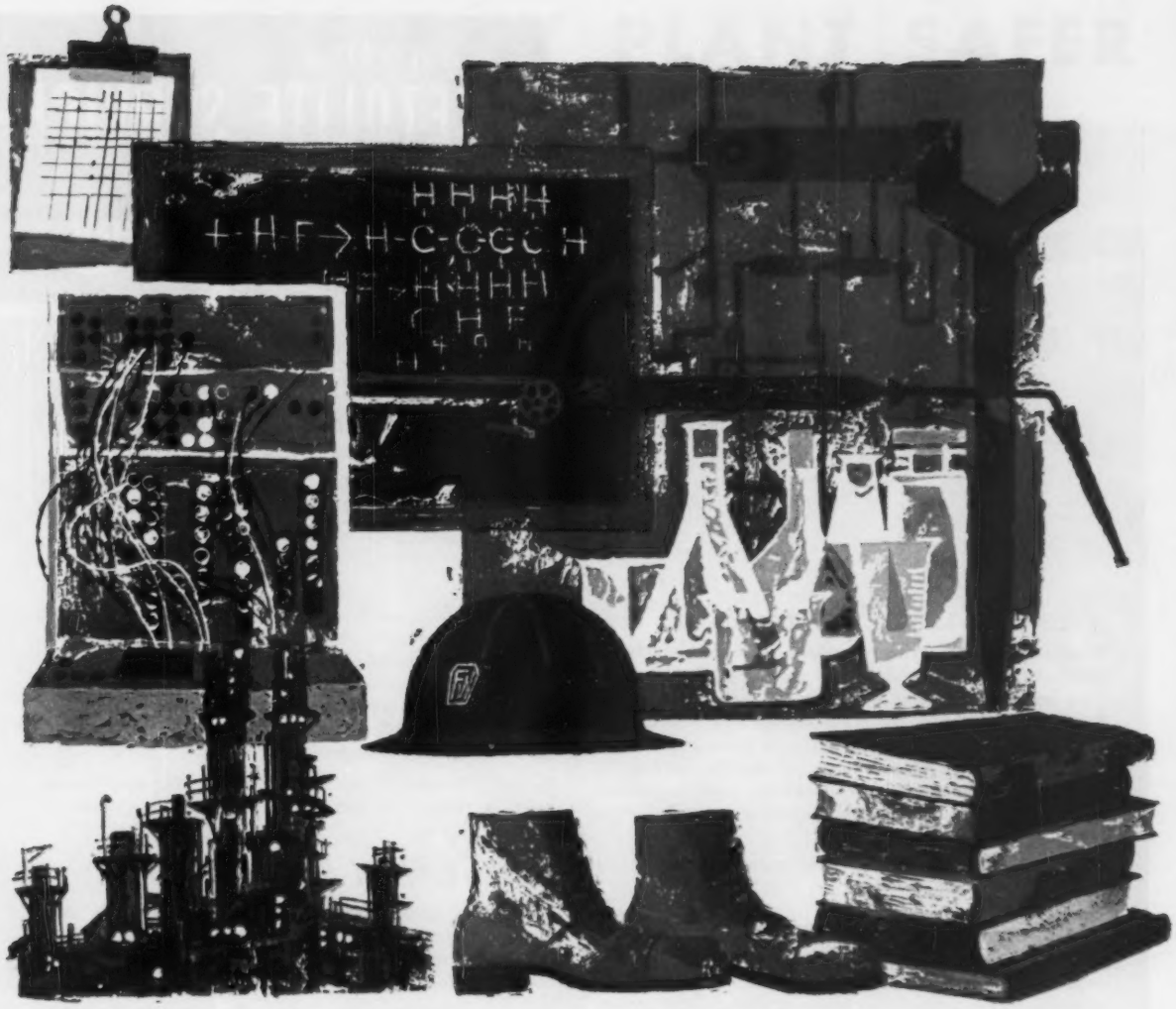

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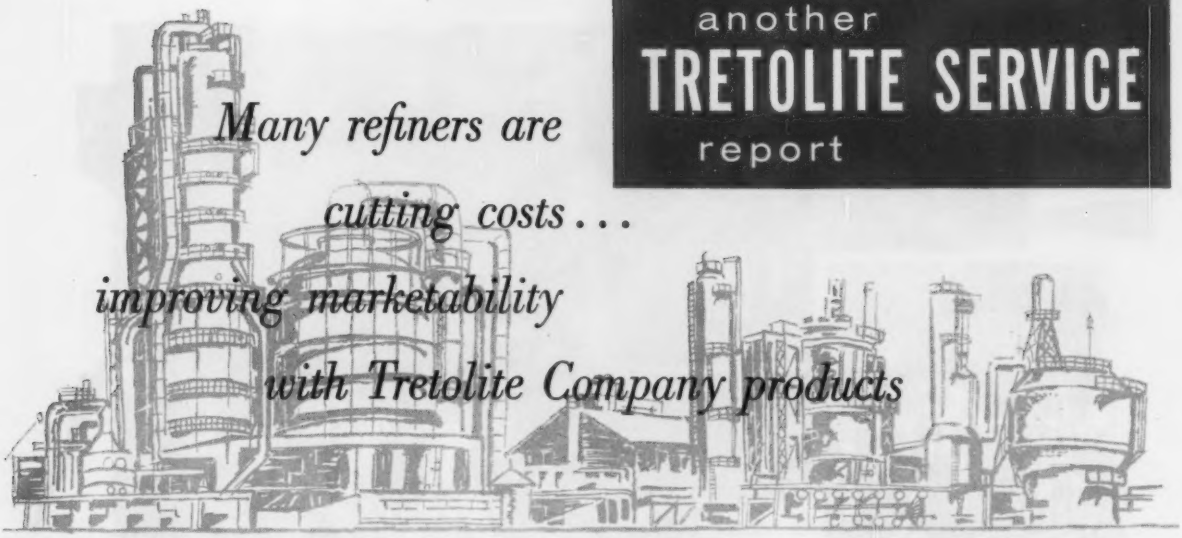

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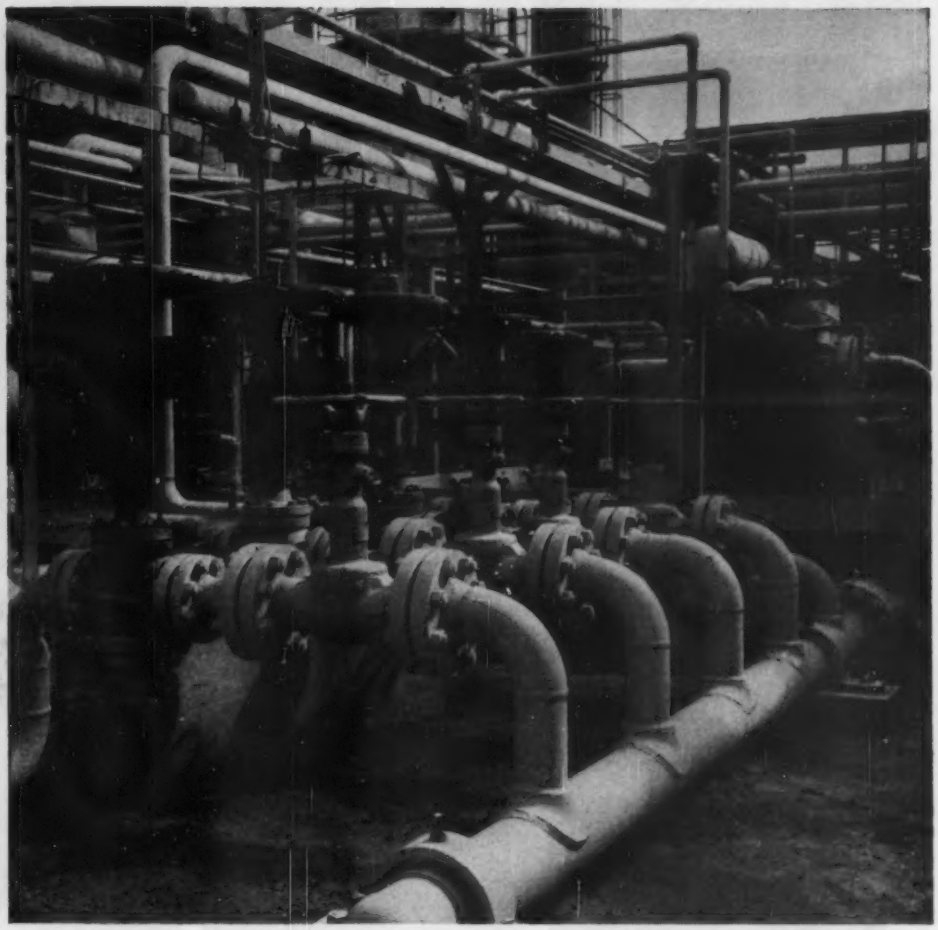

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SOURCE: Through your favorite supply house.

LITERATURE: Write Department B for Catalog 58-B.

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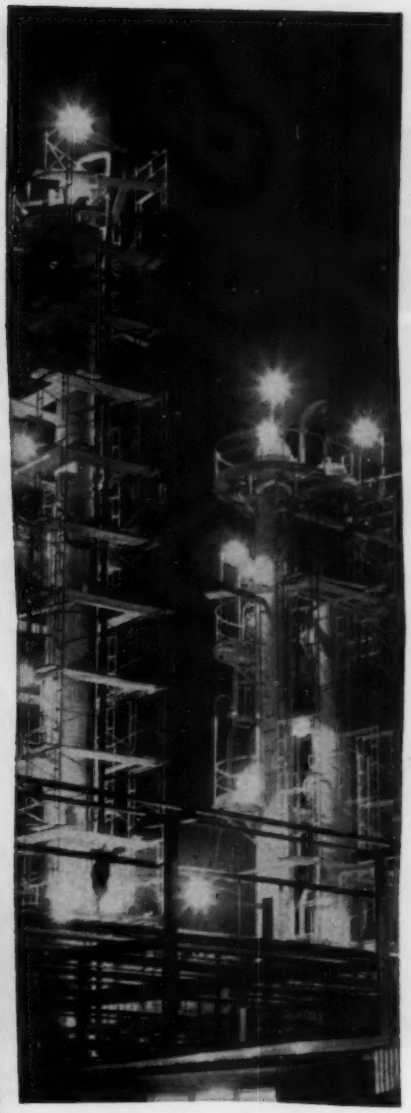

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to 550°	85% Magnesia pipe covering	block	cement
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R-P&C's complete line of bar stock valves includes constructions in 12-14 chromium stainless steel, 18-8 molybdenum stainless steel and bronze. Sizes range from ⅛" to 1" in globe and angle styles with female ends, male and female ends, or male union ends. For extremely severe throttling services, R-P&C bar stocks can be supplied with stellite discs for extra abrasion resistance.

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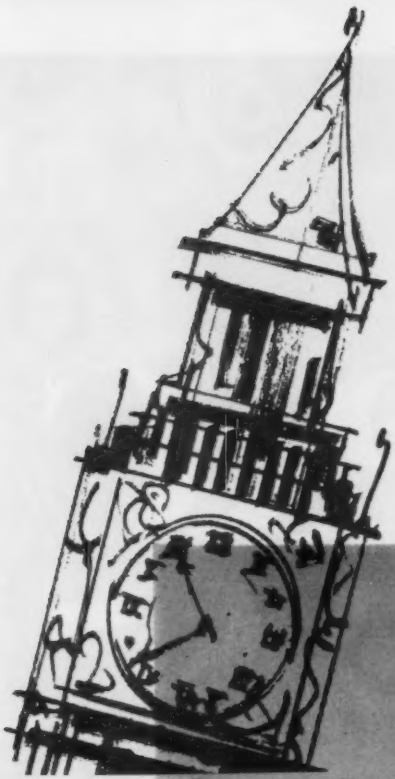

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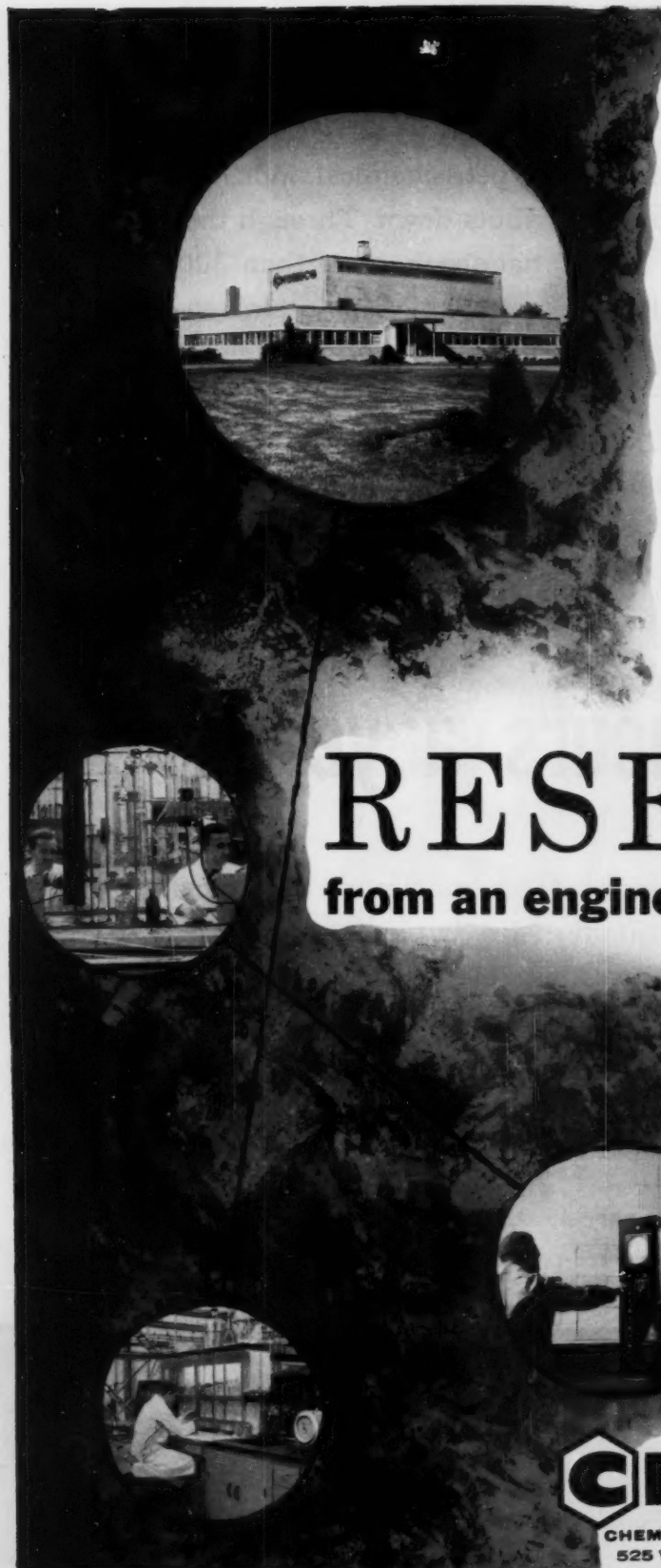

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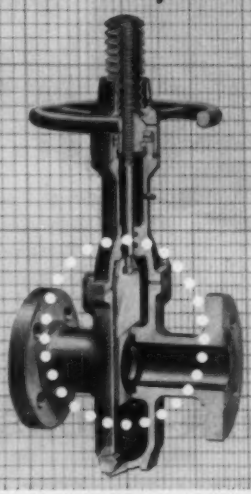

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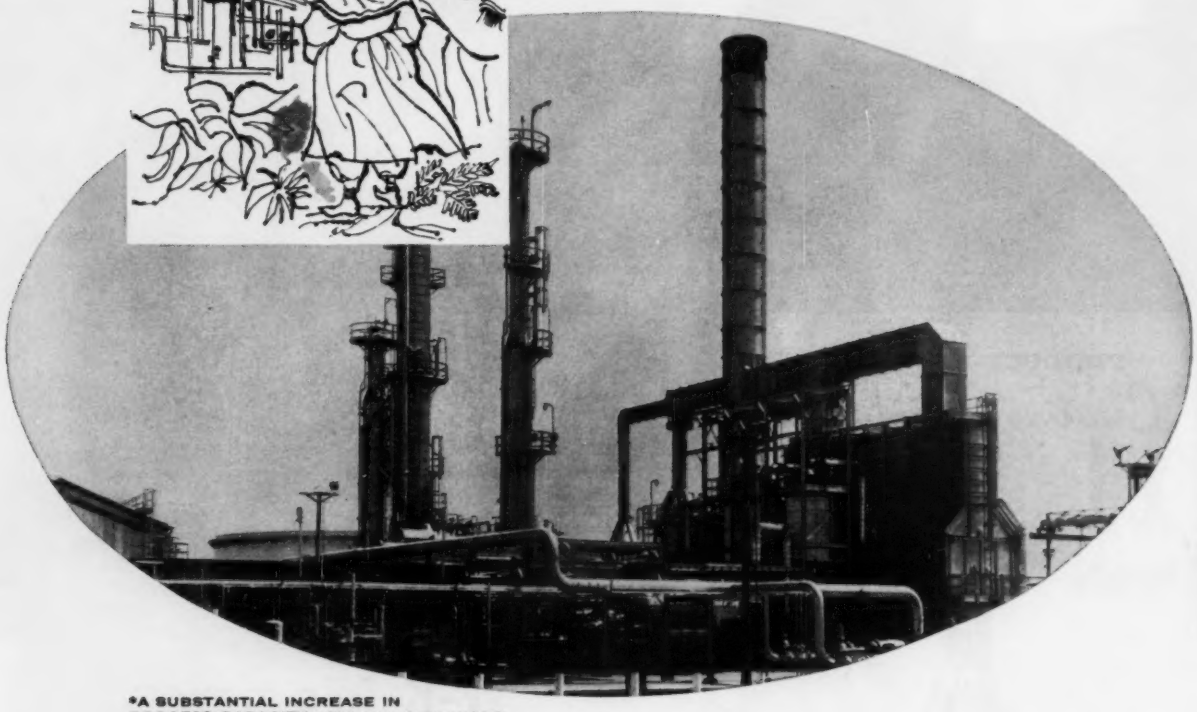

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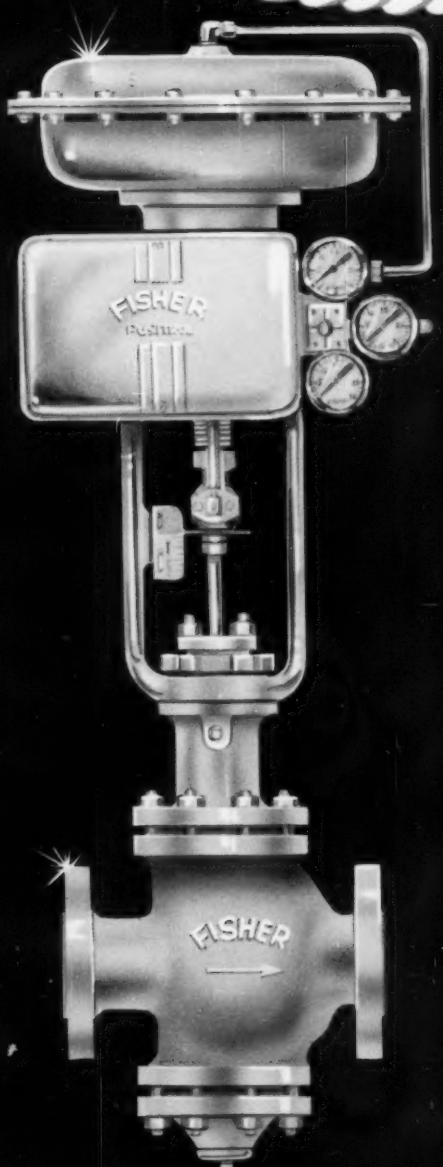

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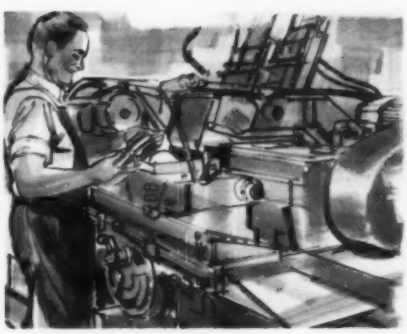

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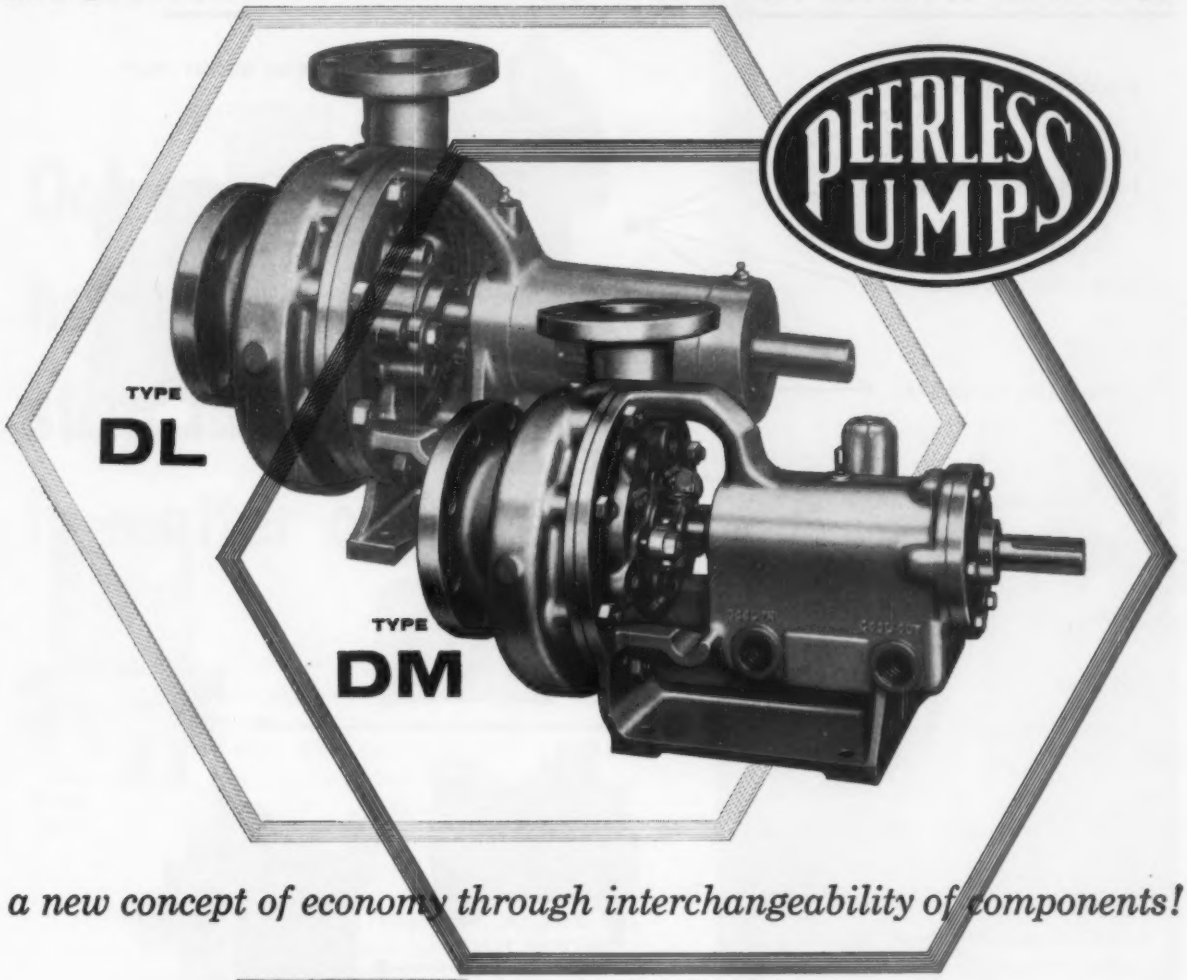

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ACCESSIBILITY—Through ease of assembly and disassembly if and when required. **DURABILITY**—Through use of any machinable metal as materials of construction. **SERVICEABILITY**—Through designs that feature maximum ease of maintenance. **INTERCHANGEABILITY**—Through a choice of semi-open or enclosed impellers, oil or grease lubrication, air- or water-cooled back plates and bearing housings. **RELIABILITY**—Through the high performance standards set for these pumps, proving more than ever before, that Peerless Builds Dependable Pumps. **AVAILABILITY**—Shipment from stock of both complete pumps and pump components.

CAPACITIES: UP TO 1000 GPM • **WORKING PRESSURE:** UP TO 300 PSIG
HEAD RANGE: UP TO 430 FEET • **TEMPERATURE RANGE:** UP TO 450° F

Putting Ideas to Work

fmc FOOD MACHINERY AND CHEMICAL

Peerless Pump Division

Offices:
New York; Detroit; Cleveland; Chicago; Indianapolis; St. Louis; San Francisco; Atlanta; Plainview; Lubbock; Phoenix; Albuquerque; Los Angeles; Fresno.

Distributors in principal cities.
Consult your telephone directory.

PEERLESS PUMP DIVISION, FOOD MACHINERY AND CHEMICAL CORPORATION
301 West Avenue 26, Los Angeles 31, California
Please send me Bulletin No. B-1608 PR

Name_____
Address_____
City_____
State_____

for this type service . . . specify this **STRONG** *trap:*

Dirty Lines or Dirty Steam:

Lowest Initial Cost per pound capacity:

Lowest Initial Cost per pound weight:

Eliminating Large Volumes of Air:

HYDRO-FLEX INVERTED BUCKET TRAP

FLOAT & THERMOSTATIC TRAP

Low Pressures with some air elimination:

Pulsating or Widely Varying Pressures:

OPEN BUCKET TRAP

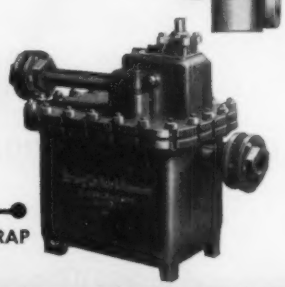
BALL FLOAT TRAP

Continuous flow required:

Draining a line carrying a vacuum discharging to atmosphere:

TYPE "A" VACUUM TRAP

Draining a line carrying a vacuum or very low pressure discharging against a hydrostatic head or back pressure:



TYPE "M" VACUUM TRAP

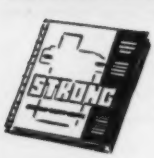
on every type service **STRONG steam traps give you longer life, less maintenance**

Strong offers six types of steam traps to answer every requirement for removing condensate from all types of systems.

You can specify these Strong Traps with the assurance that you will get maximum service life. Proof is the fact that replacement parts are still being ordered for traps sold 50 years ago!

Here are some low maintenance features built into Strong Traps. Screwed-in, replaceable valves and seats of wear-resistant ANUM-METL. Deep-drawn, one-piece stainless steel buckets. Extra-heavy body and cover construction. Thorough testing. Interchangeable parts.

You will be money and years ahead when you specify Strong Traps. For further information, contact your local Strong distributor — he carries complete stocks and replacement parts, offers prompt service.



Selector Chart in Strong Catalog No. 69A gives trap recommendations for 45 types of equipment. Write for your copy or call your distributor.

4/S

STRONG, CARLISLE & HAMMOND

508 Sandusky Street • Conneaut, Ohio

steam traps • air traps • float traps • vacuum or pumping traps
F and T traps • continuous blowdown valves • separators • engine stops

For more data on advertised products, use Readers' Service Cards, last page.

Oakite ECP
engineered cleaning program

helps two-man crew strip tank bare in matter of hours

Rust-spotted, oil-splotched and peeling, an oil storage tank cried out for repainting. But stripping the old paint and soil had previously taken many tedious—and costly—man-hours of wire brush work. When refinery called in the Oakite engineer, he drew up an ECP, including a recommendation to strip tanks by the Oakite Hot Flow-On method. A heated solution of Oakite Stripper M-3 was flowed onto the tank surface through a perforated pipe "rake," recovered in a canvas trough, and recirculated. In just a few hours a painting team had moved in and the two-man stripping crew was ready to tackle another unsightly tank.

WHAT IS OAKITE ECP? It's an *Engineered Cleaning Program* that stresses chemical cleaning. It's engineered specifically for your refinery, for your cleaning problems, and for each cleaning operation—tower by tower, valve by valve.

The Oakite engineer lends personal and experienced supervision to each phase of the program. He supplies detailed instruction based on practical knowledge of refinery cleaning needs. Each Oakite ECP is backed by a *laboratory* concentrating on chemical cleaning research, by *materials* known to make short work of refinery soils, by proved *methods*. Send for booklets. Oakite Products, Inc., 50B Rector Street, New York 6, N. Y.

SPECIALIZED INDUSTRIAL CLEANING
OAKITE
MATERIALS · METHODS · SERVICE
SCIENCE

In our 51st year.

Export Division Cable Address. Oakite

Technical Service Representatives in Principal Cities of U S and Canada

Oakite ECP
your economy key

For more data on advertised products, use Readers' Service Cards, last page.

The Right Refractory For Each Specific Need

IMPROVES BOILER

Harbison-Walker provides the most comprehensive line of Boiler Furnace Refractories

REFRACTORIES FOR MONOLITHIC CONSTRUCTIONS

Harbison-Walker Plastic Fire Brick, Castables and Ramming Mixes, comprise all the classes which are best adapted for the many different kinds of service and furnace design.

H-W Castable Refractories

These refractory concrete products all having a strong hydraulic set serve admirably for many boiler furnace and accessory uses as in pouring baffles, arches, walls, door linings, ash hoppers and sluicing troughs. Included in the twenty different brands is H-W EXTRA STRENGTH CASTABLE which is exceedingly strong and wear resistant, yet has high spalling resistance and is suitable for use at temperatures up to 2400°F.

H-W HIGH ALUMINA CASTABLE fulfills the requirements for highest operating temperatures. The several H-W Lightweight Castables combine the desirable properties of light weight, heat insulation and adequate refractoriness for their applications.

H-W Plastic Fire Brick

Harbison-Walker Plastic Refractories comprise all brands best adapted for the many different operating conditions. They form solid, joint-free linings, and are used for the construction of arches, target, baffle and bridge walls, burner ports and irregular shapes. They have physical properties closely similar to corresponding classes of refractory brick.

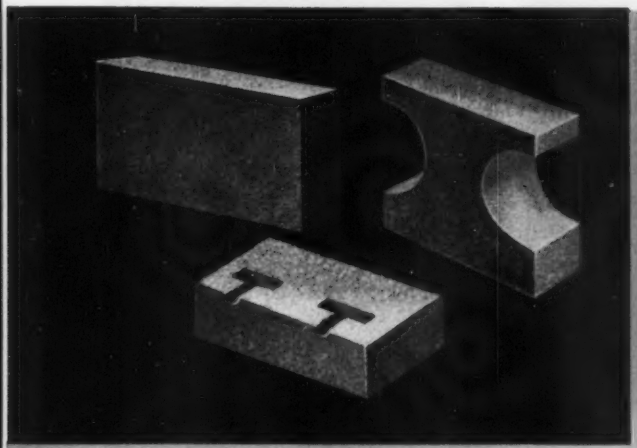
H-W STANDARD PLASTIC FIRE BRICK is a dense-burning, uniform refractory made of the same clean, high-purity flint clay of hard burn and plastic bond clay as are used in the best high duty fireclay brick.

H-W SUPER PLASTIC FIRE BRICK possesses the properties of super-duty fireclay refractories and is used economically in applications where temperatures exceed the limits for H-W STANDARD PLASTIC FIRE BRICK.

H-W SUPER PLASTIC-CS takes an air-set after drying in the low temperature range. This added strength prior to the development of the usual strong ceramic set is especially desirable for certain furnace installations.

To meet all the widely different conditions in the operation of steam power generating plants, Harbison-Walker produces the complete range of refractories from which can be selected the particular kinds for the best balance in service and economy. These refractories are manufactured in many states—and warehouse stocks are available in many cities and towns throughout North American and various other countries. Transportation time and cost benefits are obvious.

PERFORMANCE



APACHE Plastic Fire Brick is the high alumina plastic refractory which withstands the highest temperatures to best advantage and is most resistant to chemical attack by corrosive slags.

H-W Ramming Materials

THERMOLITH BATCH furnished both dry and ready mixed has a chrome ore base and because of the chemical composition and dense impervious texture developed when heated, it renders outstanding service in bottoms of slag tap boiler furnaces.

KORUNDAL RAMMING MIX (shipped dry) is a high alumina base material especially suited for use at extremely high temperatures.

HARBISON-WALKER REFRACTORY BRICK AND SHAPES WITH CORRESPONDING MORTARS

The many different brands of fireclay brick of all classes, and high alumina brick ranging up to 99% alumina, along with corresponding mortars afford the best choice for substantially every combination of conditions.

The H-W high alumina brands provide maximum resistance to exceedingly corrosive oil ash high in vanadium oxide and alkalies, ash of organic refuse including wood waste and sugar mill bagasse and certain coal clinker compositions.

H-W INSULATING REFRACTORIES

Harbison-Walker Insulating Fire Brick are made in eight different brands, each of which is suitable for use to best advantage for various sets of operating conditions. Other H-W insulating refractories are H-W BLOCK INSULATION and H-W MINERAL FIBER COATING. Included also are insulating castables ranging in weight from 30 to 85 pounds per cubic foot (weight of dense castables 115 to 180 p.c.f.) with service temperature limits from 1000°F. to 3000°F.

Technical Service based on the most extensive experience and research is freely offered to help you select the refractories best suited for your specific requirements.

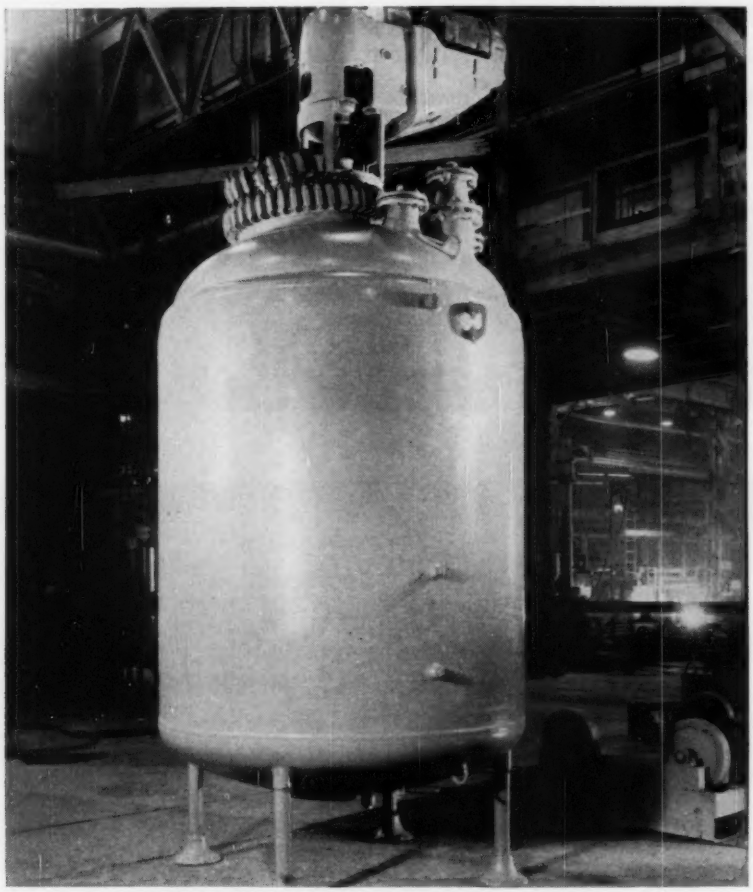
HARBISON-WALKER REFRACTORIES COMPANY AND SUBSIDIARIES

World's Most Complete Refractories Service

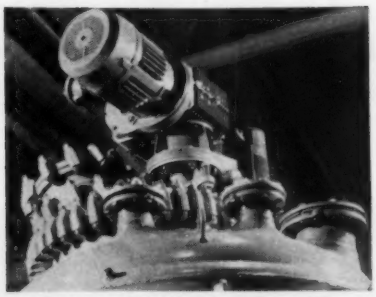
***GENERAL OFFICES:* PITTSBURGH 22, PENNSYLVANIA**

For more data on advertised products, use Readers' Service Cards, last page.

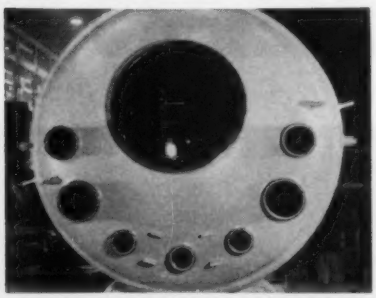
FLUIDICS* AT WORK



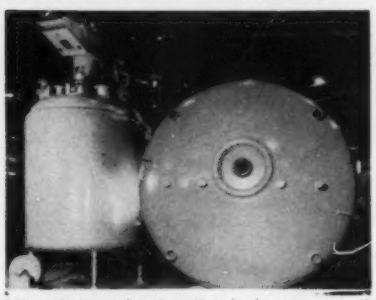
Different silhouette and light-blue exterior tell you the Pfaudler "RA" Series Glasteel Reactor is new. Unit shown has BH drive.



TW drive, one of two new drives, provides increased stability for agitator shaft. Runs very quietly.



"Mirror image" provides like-size nozzles on each half of top head. Facilitates piping.



Offset bottom head outlet is in sweep path of agitator and in line with top head manhole.

NEW from top to bottom . . . Pfaudler "RA" Series Reactors

The old "Pfaudlers" (R Series) that you're so familiar with are passing from the scene.

In their place, we now offer you the all new "RA" Series Glasteel Reactors with many significant design improvements.

Two new drives. Starting at the top you'll find the TW drive on the 300 through 1000 gallon reactors for power requirements to 15 H.P. The BH drive takes over on the 1500 gallon and larger sizes for power requirements to 60 H.P.

Both drive designs are compact, easily installed and maintained. Very quiet, too—a difference that's appreciated when operating a full line of reactors.

Mirror image top head. Next, note the equal number of nozzles on each half of the top head, placed symmetrically for ample freedom in piping. For example, you can feed two reactors from a single tee—one to the left, one to the right.

And since there are no cumbersome drive supports, you have convenient access to manhole, observation window, nozzles, drives, baffles, dip pipe and mechanical seal.

Offset drain. Off the bottom head you get fast drainage, since the outlet has been offset from center to a position in the direct sweep path of the agitator. Also, the outlet is in line with the top head manhole for convenient inspection.

Corrosion resistance. Of course, inside there's Glasteel 59. Excellent resistance to all acids (except HF) to 350° F. and on to 450° F., depending on concentration. Mild alkalies at moderate temperatures are also permissible. Thermal shock resistance is 30% over the "R" series. At a vessel temperature of 250° F. your recommended safe temperature differential is now 260° F. Abrasion resistance has also been increased by 20%. Glasteel 59 is smooth—resists build-up of sticky products. As a result, you have high heat-transfer rates, increased product yield, fewer shutdowns for cleaning, and much longer service life.

Stock delivery. Standard "RA" Series Reactors range in size from 300 to 4000 gallons. The 500, 750, 1000 and 2000 gallon vessels, fully assembled with standard drives and agitation, are pre-stocked for *two-week* delivery from receipt of your order.

Write for specifications. New Bulletin No. 988 is now available. For your copy, write to our Pfaudler Division, Dept. PR-40, Rochester 3, New York.

How to test the value of Glasteel polymerizers

Consider three important factors—purity of the polymer, amount of downtime, and initial cost. Then look at what you can expect from Pfaudler Glasteel polymerizers.

Product purity. Glasteel will not contaminate or discolor materials you use in making synthetic resins. Nor will it act as a catalyst to set off undesired side reactions.

Naturally, you also get Glasteel's unmatched acid-alkali corrosion resistance so you can project a long service life for this equipment.

Reduced downtime. Glasteel has an abrasion-resistant, smooth surface—smoother than the most highly polished metals. So even sticky substances don't adhere readily. What little does, you wash away quickly between batches using the Pfaudler glassed Spray Rinse Valve. Thus you can expect to put through more product per day.

Lower cost. Glasteel costs less—significantly so—than the alloys you probably would consider in order to protect your product's purity. Just how much you can save will be apparent after you have had a chance to discuss your needs with one of our representatives.

Complete specifications and operating characteristics are covered in Bulletin 932. We'll be happy to send you a copy.

Now, a tantalum heater as large as 124 square feet

Here you see a tantalum bayonet heater believed to be the largest ever produced. It was fabricated by Pfaudler. A special "vacuum purge" welding unit was employed to eliminate the inherent difficulties in welding this metal in the presence of atmospheric gases.

This heater is made up of 52 tantalum tubes, 1½" O.D., and 72 inches long. This adds up to 124 square feet of heat transfer area. Very efficient heat transfer, too, since the 100% corrosion resistance (in those applications where recommended) of tantalum means there's no fouling factor. Also, the high tensile strength and no need for corrosion allowance make possible thin wall construction.

As you might expect, this heater is a custom unit, and it's being assembled into a custom-made Glasteel reactor. In fact, most of the quite extensive line of equipment we make from the refractory metals is to specifications.

What we offer for your consideration is the know-how in fabricating *tantalum*, *titanium*, and *zirconium* into a broad range of items—vessels, heat exchangers, bayonet heaters, columns, burners, accessories, baffles—just about anything you might need.

For particulars write for our Bulletin 978. Or outline in general detail your specific equipment requirements.

Valveless filter ends operating expense and maintenance

Two years ago these Permutit valveless filters were installed to handle water used in process, boiler feed and drinking.

Since then they have been in satisfactory around-the-clock operation. The filter beds and underdrain systems stay clean with no evidence of blowholes or sifting of filter media through the underdrain system.

Completely automatic, these filters require no human attention in normal operation. And they cost up to 45% less than conventional automatic gravity filters because you have no valves, flow controllers, pumps or control systems.

Lots more facts in Bulletin 922. Write for a copy.

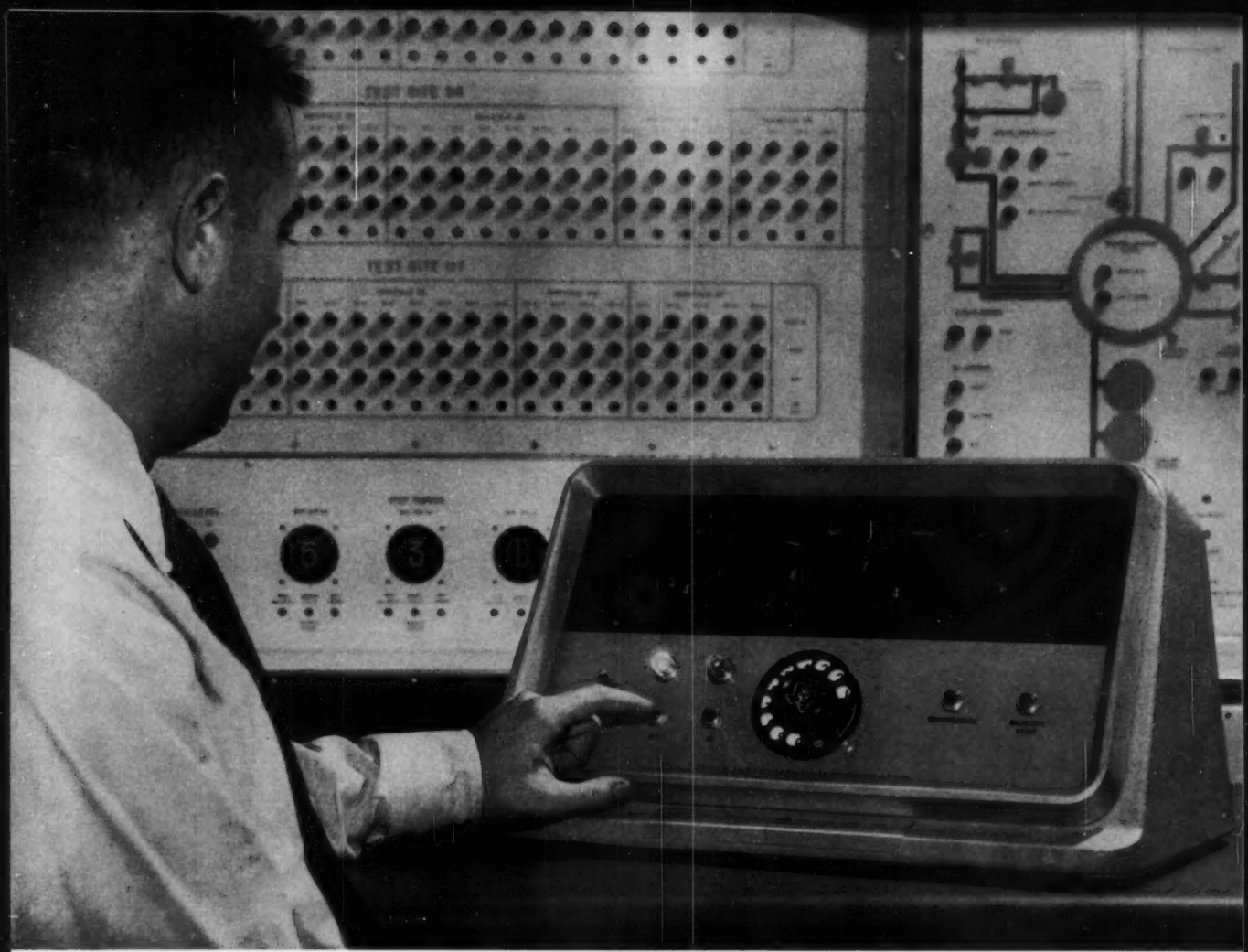
FLUIDICS AROUND THE WORLD

Pfaudler Permutit is a world-wide company with manufacturing plants in:
Germany: Pfaudler-Werke A.G.
Great Britain: Enamelled Metal Products Corp. Ltd.
Canada: Ideal Welding Co. Ltd.
Mexico: Arteacero-Pfaudler S. A.
Japan: Shinko-Pfaudler Co., Ltd.
as well as four plants in the U. S. A.

*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.

PFAUDLER PERMUTIT INC.
Specialists in FLUIDICS ... the science of fluid processes

For more data on advertised products, use Readers' Service Cards, last page.



Use the only tank gauge system specifically designed for COMPLETE MEASUREMENT-ALARM-CONTROL

DATA-GAGE* system is the only field-proved tank gauge system that provides the multi-purpose functions of measurement, alarm and control without extra, expensive control and selector equipment. And, it is the only system that performs all these functions with the high degree of accuracy and reliability you require . . . check these outstanding features carefully:

Accuracy — DATA-GAGE system measures surface level to 1/16-inch accuracy in either stationary or floating roof tanks . . . is accepted for auditing purposes by major oil companies.

Reliability — DATA-GAGE *system cannot give false information!* All binary decimal code transmissions are automatically triple-checked before data is displayed. Float must break from the fluid surface to provide readout; point connections are verified from the field; polar code eliminates possible long-short ambiguity.

Versatility — *Same equipment* provides: digital and analog measurement including accumulator readout; control for motors, pumps, pilot valves, two- and three-position valves, adjustable chokes, controller set-points, etc.; alarm indication from any sensing contact. DATA-GAGE system can be provided with automatic programmers, data loggers, alarm and status displays.

Capacity — Up to 1000 tanks can be measured for liquid level and temperature with one standard system.

Economy — DATA-GAGE system has both low initial and long-range cost. No expensive extras are required. Code lines and power lines can be run in same conduit . . . often existing ground level gauge connections and pipes can be utilized. Transistors are used instead of short-lived vacuum tubes. Easy access plug-in units make this the easiest and safest to service of all systems.

For more detailed information on the DATA-GAGE system, request Bulletin No. M-601. If you have any problems in remote measurement and supervisory control, TI application engineers can help you.

TEXAS INSTRUMENTS
INCORPORATED
GEOSCIENCES & INSTRUMENTATION DIVISION
3609 BUFFALO SPEEDWAY • HOUSTON 6, TEXAS • CABLE: TEXINS

*DATA-GAGE is a trademark of Texas Instruments. The system is licensed under Sun Oil Company patents.

"Bimetal Freeze-up" Can Be More Serious Than Dial Fogging Problem

The first sign of moisture in a dial thermometer usually shows up as condensation inside the dial glass. You are probably familiar with this dial fogging problem which causes difficult reading and the eventual corrosion of the bimetallic element. You may not, however, be familiar with another and actually more serious moisture problem —bimetal "freeze-up."

Both dial fogging and bimetal freeze-up are permanently prevented by RMC's dry air hermetic sealing process.

If moisture is sealed in, or enters a thermometer dial it will find its way to the bimetal element. Then at extreme low temperatures this moisture freezes on the element and bearing surfaces, and the bimetal element will not function should the temperature go lower. Therefore, the operator of the equipment would never know that the temperature had gone below the last indication when the element became frozen.

Here's what makes such a condition hard to spot. The thermometer would operate properly again after a temperature rise of perhaps 20°, and would continue accurate indication even though the fluid dropped again to an even lower temperature than before. However, after it remained at the new low for a few hours, it would again freeze up. Then, as before, any further drop in temperature would not be indicated.

Only a dry-air hermetic seal, as used by RMC, can prevent both dial fogging and bimetal freeze-up. RMC even goes a step further by providing for recalibration at any time without breaking the air-tight seal. An external dial reset screw—exclusive with RMC—permits recalibration without opening the instrument in any way.

New RMC 3-inch Straight Form Thermometer

RMC's 3-inch Straight Form Thermometer (Model #1740) has full view dial, parallel to stem. Stem can be located at any specified position around entire circumference of head. Has patented RMC *external recalibration device* and *silicone dampening*. Hermetically sealed.

ROCHESTER MANUFACTURING CO.
38 Rockwood St., Rochester 10, N.Y.

These RMC thermometers have just been submerged in water for the first of a severe series of tests to make sure of perfect hermetic sealing.

Moisture will never bother your RMC dial thermometer

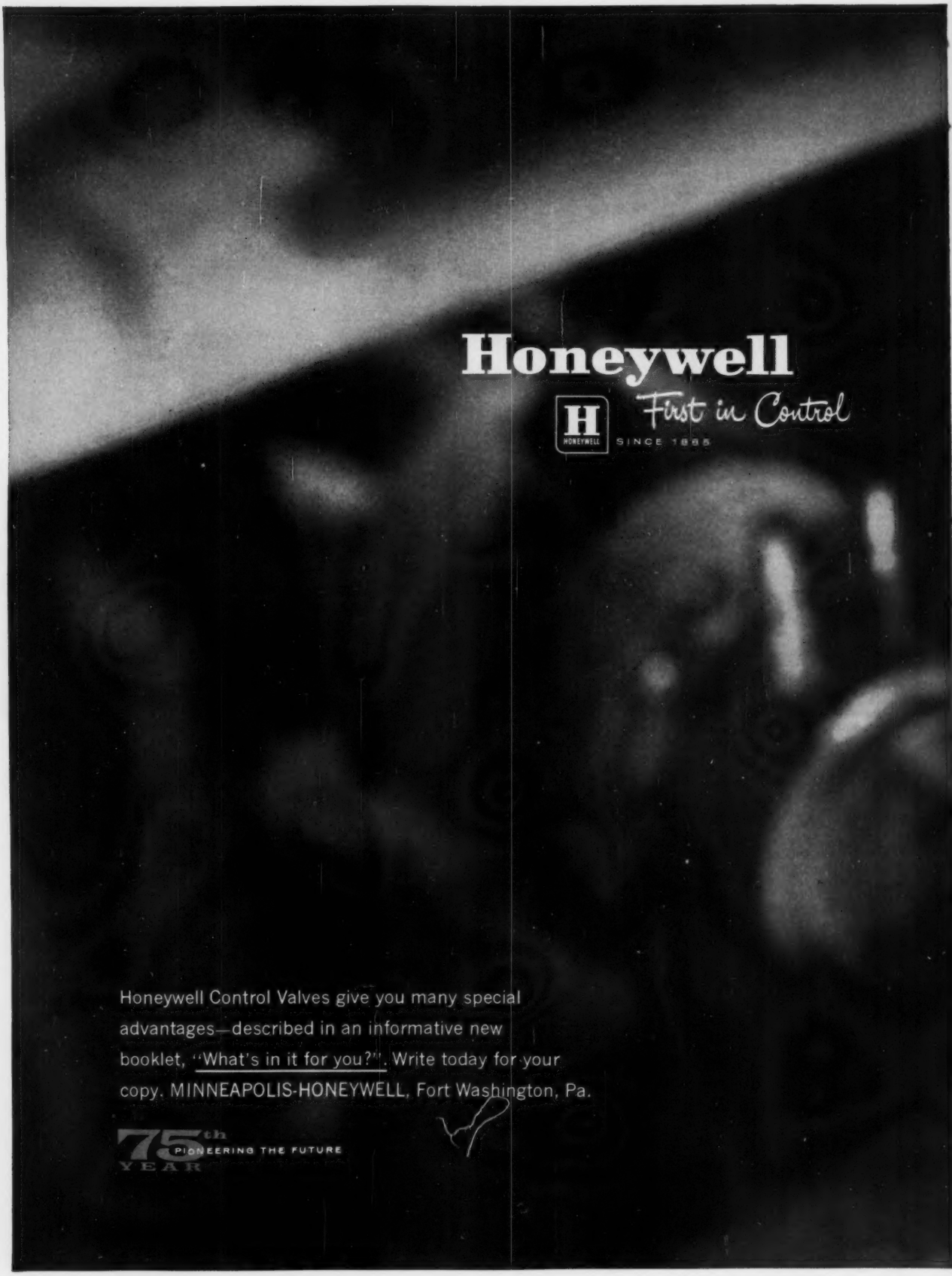
The RMC hermetic sealing process makes absolutely certain that humid air will not be sealed in the instrument and locks all moisture out permanently. Each thermometer then goes through a series of severe tests. Only those with perfect sealing are accepted for delivery. When you order from RMC you get the *only* industrial thermometer that can *never* be affected by internal dial fogging or bimetal freeze-up.

RMC

ROCHESTER MANUFACTURING CO., INC.
38 ROCKWOOD STREET • ROCHESTER 10, N.Y.

LIQUID LEVEL, TEMPERATURE and PRESSURE INSTRUMENTS

REPRESENTATIVES IN ALL PRINCIPAL CITIES


Honeywell
First in Control
H
HONEYWELL
SINCE 1885
Honeywell Control Valves give you many special advantages—described in an informative new booklet, "What's in it for you?". Write today for your copy. MINNEAPOLIS-HONEYWELL, Fort Washington, Pa.
75th YEAR
PIONEERING THE FUTURE

For more data on advertised products, use Readers' Service Cards, last page.

Passes even the "white glove" inspection—thanks to new standards of cleanness by Dow Industrial Service

You may never have occasion to apply "white glove" requirements to the cleanness of your process equipment, steam generators, tanks and piping. But, if you do need this high degree of cleanness, Dow Industrial Service can offer it — as an additional service — in the chemical cleaning of *your* plant equipment.

These new standards were developed by Dowell for cleaning the piping networks of the missile launching facilities at Cape Canaveral. Combining the research and engineering facilities of the entire company, new techniques, materials and equipment were perfected to meet the necessary rigid specifications.

This new service is now adaptable for use in all types of American industry. For example, an intricate cleaning job was recently performed on a 3½-mile-long buried pipeline. The customer wanted to convert the six-inch line from hydrocarbon gas to carry oxygen. For this pure product the line had to be immaculate—free of all foreign materials. The plant was faced with the alternate of laying new pipe—a six week job at a cost of $150,000.

Using the new standards of cleanness, the line was cleaned of hydrocarbon residues, carbon black, grease, mill scale, and rust. The cleaning job was done in 3½ days at a cost of $20,000. Meanwhile, plant crews made mechanical alterations to the line at a cost of about $25,000.

The job was satisfactory in every way. Inspection showed the line was free of all foreign matter. The customer credited the job with saving them about $100,000. Also the plant made additional profits because the line was put back into use so quickly.

Ask about these new standards of cleanness and their possible application to your problems. This exclusive service may save you important money. Dow Industrial Service offers the cleaning services formerly provided by Dowell. For engineered recommendations or more information, call the office or station near you. Or write Dow Industrial Service, 20575 Center Ridge Road, Cleveland 16, Ohio.

Chemical Cleaning Services for all industry

DOW INDUSTRIAL SERVICE

DOW

DIVISION OF THE DOW CHEMICAL COMPANY

The Mail Box . . .

Needed Saying

To The Editor:

I believe Dr. John J. McKetta said some things in the article on "How Professional Is Your Management?" (February PR, Page 190) which needed saying for some time. It should be reprinted every month for a few months just so people will have less opportunity to miss it.

C. L. Becker

Richmond, Calif.

To The Editor:

I have read Dr. John J. McKetta's article on "How Professional Is Your Management?" and I applaud your publishing it. I think his remarks about management buying manpower, but not esprit de corps, is superb.

I just couldn't resist writing and saying I enjoyed this article.

John Lenoir

Saratoga, Calif.

Reader Response

This McKetta article enjoyed a great response although some of the writers asked that their names not be used. One wrote that his management scored 90 percent except that it lost 5 points on Question 5 (re one's opportunity to carry research and design jobs into actual operation). Another comment, this from a vice president: "I am glad you put in print what has been in many of our minds for a long time. Our company is guilty of many of the actions mentioned. Your article was carried into our management meeting and one whole afternoon's discussion followed on the subject. I believe much good resulted."

Termed Excellent

To the Editor:

We would like to obtain an extra copy of the excellent "Maintenance Supervisor's Handbook" (PETROLEUM REFINER, January 1960). Would you please let us know if they are still available and how we can obtain one.

James S. Denis

Maintenance Engineer

Pittsburgh, Pa.

Editor's Note—This Maintenance Supervisor's Handbook was well received throughout the industry. We are considering expanding the material to cover each part more thoroughly and to add some extra chapters. Then we hope to publish the whole in book form.

rapid
short flame combustion
...even on residual fuel oil

THERMAL
VORTEX BURNER

Here is a versatile unit that gives rapid, clean combustion on a wide range of fuels including Bunker C, No. 6, light oil, any gas . . . even liquid organic wastes.

Combustion is 80% completed within the burner itself and takes place with a whirling, short flame that attains heat release rates of over 1,000,000 BTU/hr per cu ft. Products of combustion are clean and sufficient excess air for tempering the products may be introduced through the burner itself without causing smoke or instability.

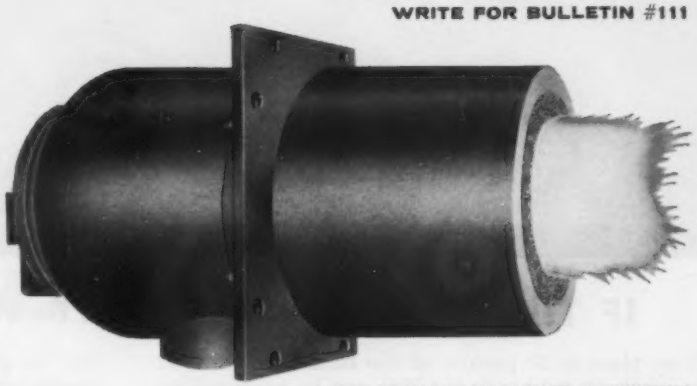
standard models available...

Complete units from 3,500,000 BTU/hr to 50,000,000 BTU/hr are available and may be fitted for steam, compressed air or mechanical atomization. With dual fuel arrangements switching from gas to oil is accomplished without shutdown.

instant ignition...

Gas-electric or torch ignition allows full ignition in a few seconds—even with a cold burner.

WRITE FOR BULLETIN #111



OTHER THERMAL PRODUCTS & SERVICES
Gas, Oil & Combination Gas-Oil Burners • Heat Exchangers • Air Heaters • Submerged Combustion • Gas Generators • Combustion & Heat Transfer Engineering

THERMAL
Thermal Research & Engineering Corp.
CONSHOHOCKEN • PENNSYLVANIA
REPRESENTATIVES IN PRINCIPAL CITIES

IF TIRES COULD TALK THEY WOULD TELL YOU:

"Very close to 50 percent of the butadiene required for synthetic rubber in the U.S. can be produced by plants using the versatile one-step Houdry Dehydrogenation Process.

"And most of this capacity has gone on stream since 1957, based on a background of serving U.S. industry for over 15 years. It is also producing butadiene in Europe, and two additional units will go on stream in Europe and Asia this year."

By direct dehydrogenation of butane, the Houdry Dehydrogenation Process can produce butene as well as butadiene, and produces other mono- and diolefins from the corresponding saturated hydrocarbons. This flexibility allows processors to switch their output to meet changing market conditions, and the changing demands of the chemical industry. Adapting the process to yield a changed end product is simple and economical.

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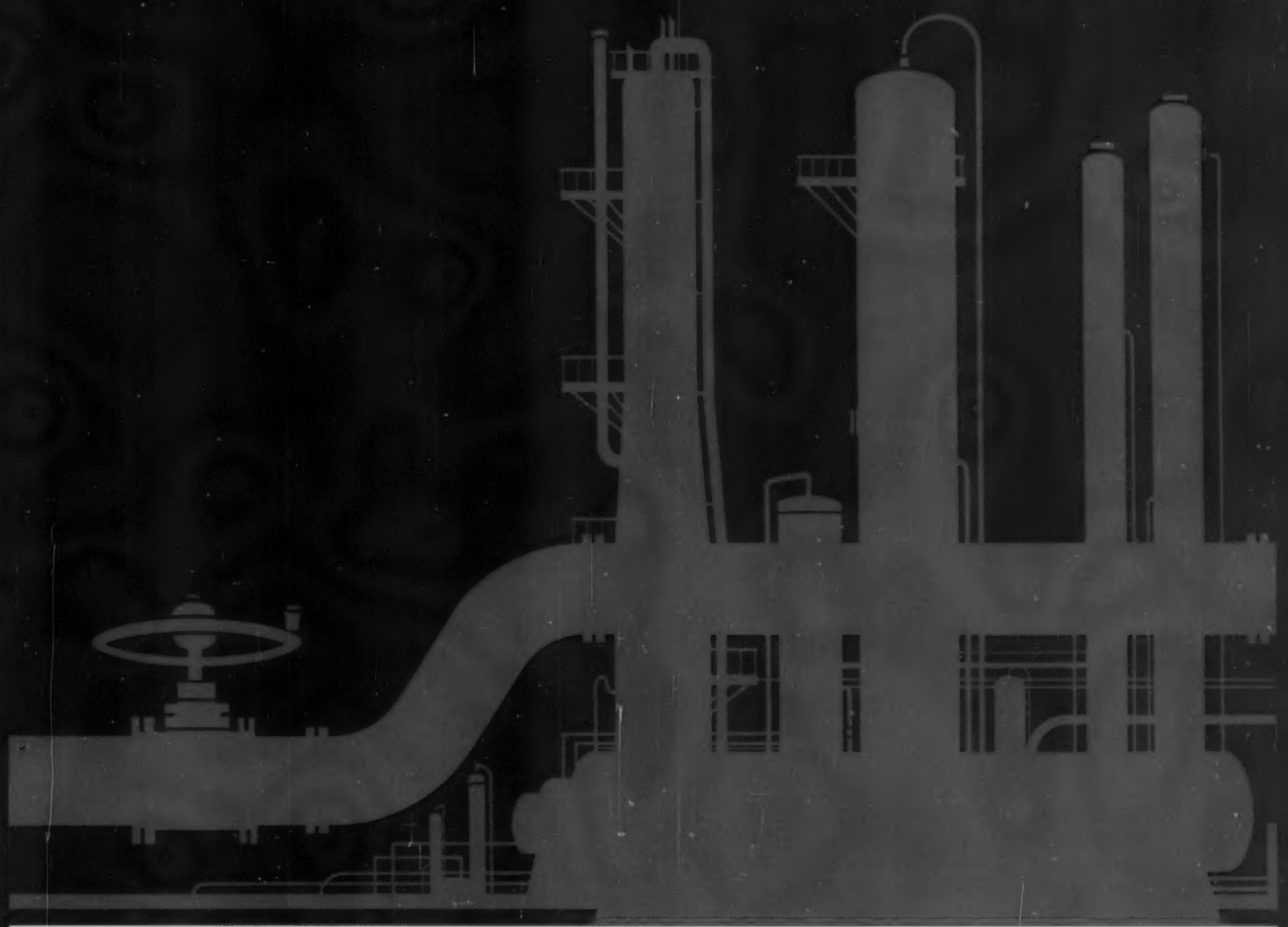
A PETROLEUM REFINER SPECIAL REPORT



NATURAL GASOLINE

Activity is building up in gas processing. More attention is being turned to maximum recovery of propane and butanes. New processes and data are now available for CO_2 removal from natural gas. Better training and maintenance methods have been found to cut costs. You'll want to check these developments in these articles: **Soup Up Older Plants for More C_3-C_4 Recovery** (p. 124); **New Data on Hot Carbonate Process** (p. 127); **Operator's Handbook for Gasoline Plants** (p. 133); and **Better Steam Boiler Maintenance** (p. 139).

A SPECIAL REPORT

SOUP UP OLDER PLANTS FOR MORE C_3 AND C_4 RECOVERY

These nine methods for increasing propane and butane recovery vary from inexpensive operational steps to major equipment additions

H. W. Barber
Phillips Petroleum Company
Bartlesville, Okla.

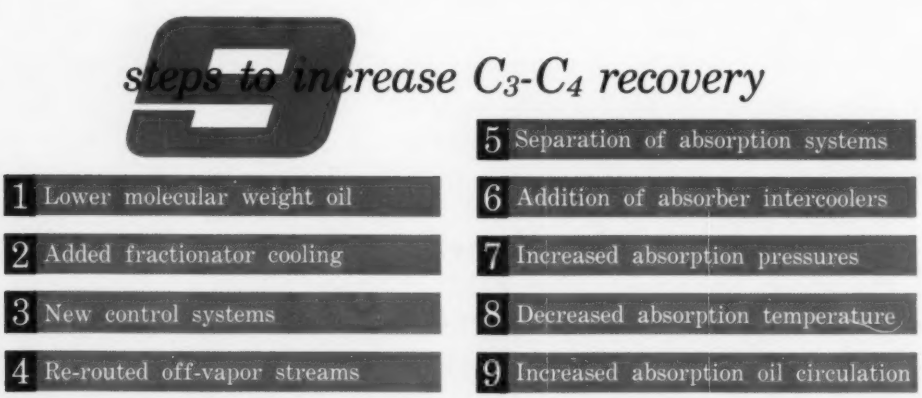
PROPANE AND BUTANE RECOVERY can be increased in many older plants with these nine methods. They vary from inexpensive operational steps to major equipment additions. All are worth investigating.

1. Lower Molecular Weight Oil. One of the first steps that should be investigated is the optimum molecular weight of the absorption medium. Often the medium used is set by past practices and its availability from other operations within the company, or in the immediate area, rather than the specific need of the plant. Also, without adequate facilities to lower the molecular weight of the oil, it tends to creep up higher than the original design specified. The molecular weight of the oil in many plants that were designed to operate with 200 M.W. oil has increased to 210-230 over a period of time.

It has been found that the molecular weight of the oil, in many cases, can be reduced to 180 and even lower, without excessive economic losses. This decrease can be effected by recharging the entire system at one time or by lowering only a part of it at a time. Decreasing the molecular weight of the oil will result in increased mole circulation which will result in increased production.

The selection of the proper molecular weight of the absorption medium is affected by the absorption pressure and temperature, the stripping facilities and other factors; however, it is a phase of operations that should be checked thoroughly. Figure 1 shows the effect of molecular weight on absorption.[1]

2. Fractionation: The fractionation and handling of the plant products should be investigated. Often excessive losses occur in the fractionation steps. The raw gasoline deethanizer is especially sensitive to overhead accumulator temperature. Since this column is operating as partially condensing, the loss of propane in the off-vapors from the reflux accumulator is critically affected by the reflux accumulator temperature. Cooling facilities should be provided to hold the accumulator temperature to a minimum without excessive operating dif-


9 steps to increase C3-C4 recovery
1 Lower molecular weight oil
2 Added fractionator cooling
3 New control systems
4 Re-routed off-vapor streams
5 Separation of absorption systems
6 Addition of absorber intercoolers
7 Increased absorption pressures
8 Decreased absorption temperature
9 Increased absorption oil circulation

ficulties. Figure 2 shows the effect of temperature.

In one plant the deethanizer reflux temperature had been running at 90° to 95° and additional facilities were provided to lower the temperature to 85° in summer time and 80° in winter time. This resulted in the recovery of a lot more propane. Sometimes it is necessary to allow the temperature to increase during extremely cold weather to guard against hydrate formation; however, the temperature should be maintained as low as possible.

Adequate cooling facilities should also be provided for the other fractionation facilities to minimize vapor losses in the operation and storage.

3. Control Systems. The use of advanced control systems in the fractionation steps in gasoline plants are being considered in a great number of plants now. In one plant a computer-controller system to control the internal reflux on a deethanizer with varying feed volumes and operating conditions was installed. In another plant a continuous chromatographic analyzer was installed to provide a continuous record of operation so immediate changes in operation could be made to provide optimum operation. These systems have not been in operation long enough to completely evaluate them. Their purpose is to prevent this: setting up operating conditions to take care of the most severe conditions which result in excessive losses during less severe conditions. Also, the more accurate control system will allow the plant to operate nearer the specifications and cut down on the safety margin.

These systems are examples of the use of new advances in control systems that can be applied to soup-up old plants. However, in considering their use, one should properly evaluate the installation and repair costs as well as the availability of personnel adequately trained to maintain them.

4. Off-Vapor Streams. Another step in souping-up old plants is a careful appraisal of the off-vapor composition and flow. In one plant various off-vapor streams were combined and routed to a reabsorber. It was necessary to operate the reabsorber at the pressure of the lowest pressure stream of approximately 200 psig. Recompression facilities were provided to boost the lower pressure streams to higher pressures and the reabsorption pressure was increased to 600 psig. This resulted in an appreciable increase in propane production with the same oil circulation.

Oftentimes, changes in inlet gas volumes and compositions, as well as operating conditions, will materially change the composition of an off-vapor stream so that it should be diverted to another point in the plant flow.

In a plant that had been operating for a number of years, a primary flash tank vapor stream was routed to the absorber inlet. A plant study revealed that increased producion would result if the vapors were combined with the still overhead vapors and routed to the raw gasoline make tank.

When evaluating the rerouting of a vapor stream, one must be careful to determine the effect on auxiliary equipment and other recycle streams. The problem of building up excessive recycle streams is particularly important if the inlet gas has a high ethane content.

5. Separation of Absorption Systems. The separation of inlet gas streams of different content and processing them in separate absorbers at different oil rates to effect optimum recovery should be reviewed where applicable. One existing plant was set up to handle rich separator gas; however, there was a relatively small stream of high pressure lean gas that came into the plant and commingled with the rich gas on the inlet to the absorbers. Over a period of years, the lean gas volume increased to a substantial volume. Plant production was increased by isolating the lean gas in a separate absorber and reducing the oil to that absorber and increasing the oil to the other absorbers to maintain optimum plant recovery.

In some cases oil can be made to serve more than one absorption system when these systems operate at different conditions. In a plant that processes a portion of the gas at low pressure and a portion at high pressure, the rich oil from the low pressure absorber is being pumped

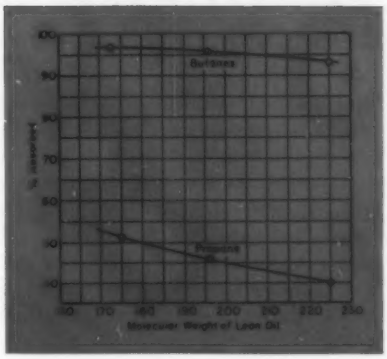


FIGURE 1—Decreasing molecular weight of absorption oil will increase recovery of butane and propane. This data is from a 600 psig absorber, with a circulation rate of 10 gallons lean oil per Mcf.

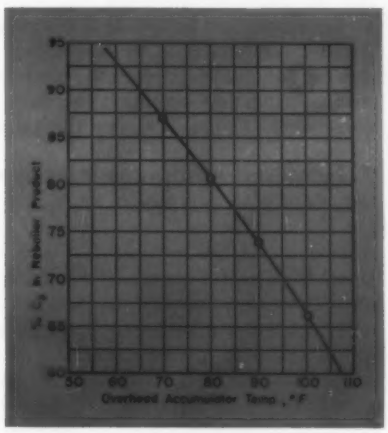


FIGURE 2—Propane retention in the deethanizer bottoms (at 450 psia) increases like this with decreasing temperature in the overhead accumulator.

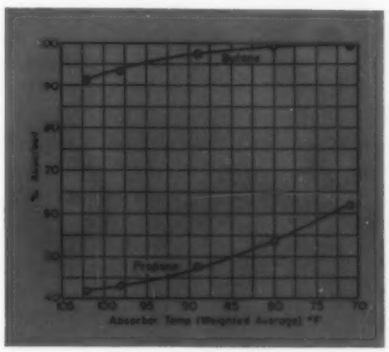


FIGURE 3—Absorber temperature has big effect on percent propane absorbed.

into the high pressure absorber several trays below the top. Even though the rich oil is in equilibrium with the gas at low pressure, it is able to absorb additional components at the higher pressure.

In another plant flow, rich oil from a high pressure *lean* gas absorber was flooded into another high pressure *rich* gas absorber at a point below the top tray. The lean gas absorber rich oil picked up additional gasoline due to the different equilibrium conditions in the rich gas absorber.

6. Absorber Intercooler. It may be economical to decrease the absorption temperature by the use of intercoolers. In this system the oil usually is drawn out of the absorber a few trays down after it has picked up a temperature rise from the initial absorption. Usually the old plant absorbers are not constructed so an intercooler system can be installed. Somewhat the same effect can be accomplished by contacting the lean oil with the residue gas in a separate vessel or pipeline blending arrangement and cooling to remove the initial heat of absorption. Figure 3 shows the effect of temperature.

7. Increased Absorption Pressures. In most plants, the absorption pressure is set by the required pressure for the residue gas sale. However, in some cases the disposition of the residue gas is changed to a higher pressure. The economics of installing a higher pressure absorber and processing the gas on the discharge of the compressor should then be investigated. One plant was called upon to deliver a portion of the residue gas at a higher pressure than the primary delivery for repressure use. It was economical to install a higher pressure absorber to handle the gas used for repressure purposes and obtain the benefit of the higher pressure for absorption.

8. Decreased Absorption Temperature. There are various ways to decrease absorption temperature. If the oil or gas to the absorber is running above 90° F, the possible addition of water cooling equipment to reduce the temperature should be investigated. Also, the use of water cooled intercoolers on the oil, as already outlined, should be considered.

The use of refrigeration of oil and/or gas is becoming increasingly popular. Various factors contribute to this processing scheme, among which are (1) the increased demand of LPG, (2) the decreased cost of refrigeration equipment, (3) processing of leaner gas, and (4) availability of better heat and equilibrium data.

When evaluating a refrigeration system, several types of design must be considered. Most old plants use steam for stripping which results in an absorption system that contains water. This limits temperature to the 55° F-to-60° F range if dehydrating facilities for the oil and/or gas are not installed.

A refrigeration system was installed in a plant to chill the oil to 60° F. This plant used steam for stripping so this 60° F range of refrigeration was selected because this could be accomplished without the cost of any dehydrating facilities. The chilled oil in this plant is pumped over the absorber. Calculations indicate that, if the absorbers had been equipped with a draw-off tray below the top, it would have been better to refrigerate the oil from this tray after some absorption had taken place.

The feasibility of chilling the oil and gas to a much lower temperature should be investigated. The required dehydration of lean oil can be effected by stripping the hot oil from the still with hot vapors or, under certain conditions, by injecting glycol into the oil. If the latter method is used, it is recommended that the system be tested first to determine the glycol losses.

Dehydration of the gas can be accompanied by injecting glycol into the gas stream ahead of the chillers and drawing off the glycol from the condensate gasoline. In some cases the gas is dehydrated in a separate contactor ahead of the chillers. A typical revamping project specifies that the oil and gas will be chilled to 10° F. In this case the oil is steam stripped to remove the absorbed gasoline and then stripped with hot vapors to remove the water. Glycol will be pumped into the gas stream ahead of the chillers and drawn off from the condensate gasoline tank.

9. Increased Oil Circulation. When considering increased oil circulation, the problem should be studied step-wise. This calls for determining the first equipment bottleneck, removing this one, and then going to the next. For instance, installing a second oil pumping unit and correcting any pressure drop bottlenecks may allow increased circulation during the cooler months when the cooling equipment is more efficient, the gas possibly leaner and normal production lower. This and any other relatively cheap steps that will provide increased production during the winter months might prove quite attractive because this is usually the period when LPG product prices are the highest.

In one plant the oil circulation was curtailed by the heating furnace capacity. A study revealed that another tube arrangement, that was relatively simple, would provide additional capacity and allow increased oil circulation. In another plant the steam stripping still was the bottleneck. Tests showed that reduced steam rate to the still would allow increased circulation. The reduced steam rate did not strip the oil as thoroughly as previously, but the advantage of the increased oil circulation more than offset inefficiency of the small amount of gasoline left in the lean oil.

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[1] E. A. Harper, "Kerosene as Absorption Oil—How Good," PETROLEUM REFINER, May 1959.

About the Author

Harold W. Barber is chief process engineer for the Natural Gasoline Department, Phillips Petroleum Company, Bartlesville. After graduating from Oklahoma State University with a B.S. degree in mechanical engineering, he went to work for the Phillips Natural Gasoline department at Borger in 1942. He has held successive jobs of construction project engineer, process engineer, process design supervisor and district engineer for the company's Western district. Before his present promotion in 1959, he was chief economics engineer.

A SPECIAL REPORT

NEW DATA FOR HOT CARBONATE PROCESS

- Regeneration efficiency of five commercial plants is compared to pilot plant data
- Ejectors decrease steam consumption in example worked out here
- Pilot plant data show simultaneous removal of hydrogen sulfide and carbon dioxide

H. E. Benson* and J. H. Field
Bureau of Mines, U.S. Department of Interior
Pittsburgh, Pa.

NEW DATA on the hot potassium carbonate process for purifying acid gases shows how capital costs and steam requirements can be reduced.

Since the development of this process by researchers of the Bureau of Mines at Bruceton, Pa., in 1954,[1] about 30 plants using this technique have been placed in operation or are under construction.[2, 3, 4] The advantages of lower plant investment and lower steam consumption offered by the method led to its adoption in preference to other systems where there is sufficient pressure of the feed gas. Hot carbonate purification plants are being used to remove carbon dioxide and hydrogen sulfide from ammonia synthesis gas, refinery hydrogen, oil gas, coal-derived Lurgi gas, and natural gas.

More recently, the continuing pilot-plant investigations by the Bureau of Mines have determined steam consumption of the process when reducing residual carbon dioxide concentration to extremely low levels of approximately 0.02 percent. In addition, the simultaneous removal of hydrogen sulfide and carbon dioxide has been explored in considering its application in purifying synthesis gas and natural gas. For purification of natural gas (even very sour gas of high acid gas content) hydrogen sulfide concentrations can be reduced to the usual pipeline specifications of 0.25 to 1.0 grains per 100 cubic feet. Although some installations for treating

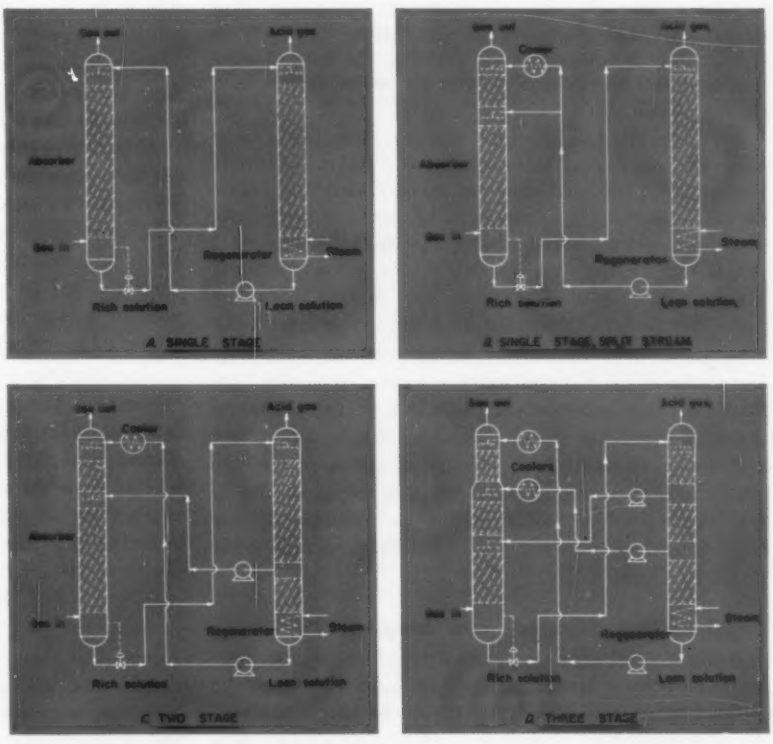

FIGURE 1—Flow schemes for hot carbonate process show flow variations.

* Present address: Consolidated Natural Gas Company, Pittsburgh, Pa.

natural gas use an amine follow-up to reduce the residual hydrogen sulfide concentration to low levels, later pilot-plant results indicate such amine installations generally are not necessary.

Flow Schemes. Some of the variations in stream flow that can be used in hot carbonate purification are illustrated in Figure 1. The choice of the type of flow depends upon the concentration of the acid gas in the feed, the degree of purification required, the pressure of absorption, and the value of the steam used for regeneration. When steam costs are high, additional capital costs for a more complex system are justifiable so less steam will be required for regeneration.

Single-stream flow, Figure 1(A), is the simplest and usually is lowest in capital costs. The total lean solution from the regenerator is pumped to the top of the absorber without cooling. The rich solution leaving the absorber is depressurized and sent to the regenerator. Solution heat exchangers or coolers are not used and the capital investment thus is lower.

In single-stage, split-stream operation, Figure 1(B), the lean solution is divided before it is fed to the absorber. The smaller portion is cooled to lower the equilibrium back pressure of the acid gas, and then is fed to the top section of packing. Cooling to a point between 30° and 60° F usually suffices. The main stream is fed to a lower point of the absorber without cooling. The residual concentration of the carbon dioxide and hydrogen sulfide in the purified gas can be lowered further compared with single-stream operation. The only modification required in the system from single-stream flow is equipment for dividing the flow of solution and the installation of a small cooler in the split-stream circuit.

To lower the equilibrium further, back pressure of acid gas over the split-stream, two-stage operation, Figure 1(C), is used. In this modification the entire rich solution, after being depressurized, is partly regenerated in the main (upper) section of the regenerator, but the main stream is withdrawn before reaching the bottom section of packing. The smaller stream is more effectively regenerated by being treated with the total quantity of steam in the bottom section of packing. For example: If the split stream is one-fourth the total flow, the steam-to-solution ratio is four times that of single-stage regeneration for the same total solution flow and steam consumption. This type system is used to obtain a high degree of purification. Further staging to regenerate portions of the solution to different degrees can be used as shown by the three-stage system illustrated in Figure 1(D).

Regeneration Efficiency and Staging. The choice of a single stage, single stage with split stream, or a two-stage carbonate system will depend chiefly upon the amount of carbon dioxide that is to be left in the gas. To a lesser extent it will depend also upon the costs and availability of low-pressure steam.

A guide for selecting the type of system required to obtain a specified purity of gas is presented in Figure 2. The range of regeneration efficiencies possible at various partial pressures of carbon dioxide in the feed gas is shown as a function of the percentage of carbon dioxide concentration in the purified gas. Gas volumes here refer to 60° F, saturated with water vapor. Generally, with the gas at a pressure of 20 atmospheres or higher, a one-stage installation is adequate when the carbon dioxide is to be reduced to about 1.5 percent. In the range from about 0.8 to 1.5 percent carbon dioxide, a one-stage unit with split-stream cooling usually to about 190° F is recommended. If the goal is a reduction below 0.8 percent carbon dioxide, a two-stage installation is desirable to reduce the residual carbon dioxide to the indicated level with high regeneration efficiencies.

The recommended areas of operation are based on a balance between the regeneration efficiency attainable for the various flow systems and the capital cost of these systems. There will be situations where, because of fuel charges, larger capital expenditure in the form of larger towers will be justifiable. On the other hand, when a plant has a surplus of low-level steam, one can reasonably operate with lower regeneration efficiencies and smaller capital investment. The tower dimensions assumed are in the usual ranges of commercial practice as to height and diameter. Obviously an allowance must be made for some overlapping of the zones of Figure 2.

The two-stage system is recommended for scrubbing to low levels of carbon dioxide (below 2.5 psi partial pressure) because the regeneration efficiency for a single-stage system decreases more rapidly with increasing degree of removal in this range. Steam consumption can be kept to a minimum in reducing carbon dioxide to low levels by staging, large size towers, and (to a lesser extent) increased circulation of solution.

A study of pilot-plant and commercial data shows that it is possible to remove carbon dioxide to about 0.05 percent in two stages. If removal to the range of 0.01-0.02 percent carbon dioxide is desired, this can be done by incorporating a third stage, Figure 1(D), without increasing the steam beyond that required for two stages. The three-stage system has been simulated in the pilot plant by operating only the last two stages of the three-stage system. In these experiments, the carbon dioxide content was decreased from 1 to 5 in the feed gas to 0.01-0.02 percent in the purified gas.

Considerable pilot-plant work has been done by the Bureau of Mines to evaluate the performance of the hot carbonate system with various mixtures of carbon dioxide and hydrogen sulfide. More results of this work will be reported soon in Bureau publications. As a generalization, we can state that regeneration efficiencies reflected in Figure 2 can also be expected from a system designed to scrub both hydrogen sulfide and carbon dioxide. When both of these acid gas impurities are present, the partial pressure of the acid gas used in Figure 2 is the sum of the partial pressures of carbon dioxide and hydrogen sulfide. The values in the abscissa, however, refer only to carbon dioxide, as residual hydrogen sulfide values would be much lower as will be shown later in this paper. The carrying capacities of

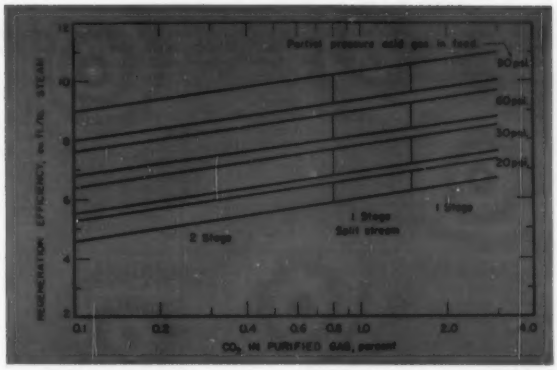

FIGURE 2—Effect of operating conditions on regeneration efficiency (300 psig absorption pressure) guides selection of system to get a specified gas purity.

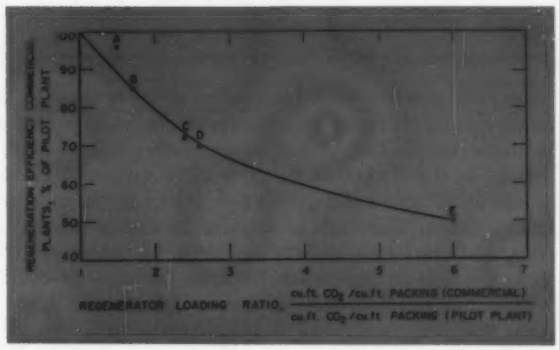
REGENERATION EFFICIENCY COMMERCIAL PLANTS, % OF PILOT PLANT
REGENERATOR LOADING RATIO, cu. ft. CO2 /cu. ft. PACKING (COMMERCIAL) / cu. ft. CO2 /cu. ft. PACKING (PILOT PLANT)

FIGURE 3—Regeneration efficiency of five commercial plants shows varying approach to pilot plant efficiency.

the carbonate solution and regeneration efficiencies are greater for hydrogen sulfide than for carbon dioxide when purification under the same inlet and outlet gas concentrations is accomplished. Therefore, the regeneration efficiencies of Figure 2 are conservative when hydrogen sulfide is a component of the acid gas.

Commercial Plant Performance. The scale-up from pilot-plant to commercial operation is a major problem faced by the process engineer. For the commercial plant, the design of process equipment is based upon the minimum cost; that is, both the capital investment and the operating cost. Thus, in the design of heat exchangers the size and cost of the exchanger depends largely upon the value of the heat unit for the particular installation. A similar situation exists in determining the size of the absorption and regeneration columns for a hot carbonate system because the heat required for regenerating the solution is related to the approach to equilibrium in the towers. If one desires to minimize steam requirements because of the high cost of steam or inadequate supply, the size of the columns should be relatively large to obtain a close approach to equilibrium. However, if there is an ample supply of low-cost steam, it would be advisable to decrease the size of the columns, thereby keeping the capital investment down.

The circulation rate of the solution also is affected by the column design. If the regenerator is relatively small, a greater driving force is required to strip the acid gas. Consequently, either less regeneration of the solution will occur for a fixed steam input, or a larger steam input will be required for a given degree of regeneration. When too little regeneration is achieved, a greater rate of solution circulation is required to effect the desired removal of acid gas.

The effect of the size of the regerenator in several commercial hot carbonate plants to the steam consumption for regeneration is shown in Figure 3. Here the regeneration efficiencies (cubic feet of acid gas per pound of steam) for five commercial plants expressed as percent of pilot-plant regeneration efficiency (for the same partial pressures of carbon dioxide in the feed and scrubbed gases) are shown as a function of regenerator loading ratio. The regenerator loading ratio is defined as the cubic feet of acid gas transferred per cubic foot of regenerator packing for the commercial plant divided by the cubic feet of acid gas transferred per cubic foot of regenerator packing in the pilot plant for the same conditions of gas concentration, pressure, and solution circulation rate.

Where regenerator loading is greater (i.e., the regenerator is smaller relative to the pilot plant) it is necessary to use more steam for regeneration. Thus in the case of plant E, where six times as much carbon dioxide was removed per cubic foot of regenerator packing, as done in the pilot plant, the regeneration efficiency is only 50 percent that of the pilot plant. The same sort of relationship could be shown for the absorber. If commercial columns are operated with less acid gas removal per volume of packing than the pilot plant, it is possible to obtain a greater regeneration efficiency than in the pilot plant.

Table 1 gives the range of solution concentrations and acid gas pickup that may be expected in plant operation and are being employed in commercial plants.

TABLE 1—Solution Concentration and Acid Gas Pickup

Partial Pressure Acid Gas, lbs./sq. in.	Solution Concentration, % K_2CO_3	Acid Gas Pickup, cu. ft./gal.
90—150	25—35	3.5—5.0
60—90	25—35	3.0—4.0
40—60	30—40	2.5—3.7
20—40	30—40	2.0—3.3

These values are obviously subject to the size of the absorption and regenerator columns and the approach to equilibrium obtained therein. For the relatively large columns, the acid gas pickup will be at the upper end of the range shown in Table 1, and as explained previously regeneration efficiency will be high. Variation of the concentration of the solution obviously affects the acid gas pickup. For a given partial pressure of acid gas in the feed, a lower pickup results with increasing dilution. However, the decrease in pickup is not directly proportional to the amount of dilution. This is because of other influences, such as the effect of concentration on absorption rate and equilibrium back pressure over the solution.

Decreasing Steam Consumption by Use of Ejectors. In some situations, further reduction of steam requirements for regeneration of the carbonate solution may be realized by using steam ejectors. The regenerated carbonate solution can be sent to a flash tank (Figure 4)

where the pressure is maintained at a lower level by a steam ejector. Because the solution at the lower pressure is above the boiling point, steam flashes and is compressed by the ejector to the pressure in the regenerator. Steam at 50 psig—and preferably higher—is used as motive steam. The flash or entrained steam is nearly as effective in stripping carbon dioxide or hydrogen sulfide from solution as the steam from the reboiler or other source. The small amount of carbon dioxide (0.1-1 percent) that may be present in the flashed steam does not interfere significantly with the effectiveness of the stripping operation.

To illustrate how this technique may be used to decrease steam consumption, two cases have been worked out as a comparison using the following conditions:

Raw gas flow of 25 MMcf per day, 30 percent carbon dioxide purified to 0.2 percent gas at 300 psig, 35 percent potassium carbonate solution, carrying capacity of 3.7 cubic feet carbon dioxide per gallon, main stream flow of 63,300 gallons per hour, split stream flow of 21,100 gallons per hour, carbon dioxide removal of 311,000 cubic feet per hour. The feed gas temperature and degree of saturation with water vapor has little effect upon the results.

Table 2 summarizes the steam requirements of the hot potassium carbonate system both with and without steam ejectors.

Case I is for operation without ejectors and Case II is with steam ejectors. In this calculation the split stream was cooled 36 degrees by flashing from 232° F, the usual extent of cooling recommended for the split stream. The main stream was cooled also, to 211° F from 232° F, by flashing and use of ejectors. The amount of steam recoverable by flashing is calculated from a heat balance. About 10 percent of the total steam required was assumed to come from a reboiler to allow for control of solution concentration.

TABLE 2—Steam Savings by Use of Ejectors

Plant capacity 25,000,000 CFD, 30% CO_2, 3.7 cu. ft. CO_2/gal. carrying capacity, 35% solution, purification to 0.2% CO_2, main stream 63,300 gph, split stream 21,100 gph, absorber pressure 300 p.s.i.g.

Temperature, °F	CASE I Without Flash Cooling	CASE II Flash Cool Split Stream to 196° F. and Main Stream to 211° F.
Regenerator main stream:		
Before flashing	232	232
After flashing	.....	211
Regenerator split stream:		
Before flashing	232	232
After flashing	.....	196
After water cooling	196	.....
Steam used, lb./hr.:		
Direct	30,000	.....
Ejector, motive (150 p.s.i.g.)	.....	13,600
Ejector, entrained	.....	17,300
Reboiler	4,700	3,800
Total	34,700	34,700
Total external steam[a]	34,700	17,400
Steam savings, lb./hr.	.....	17,300
Regeneration efficiency, ft.³ CO_2/lb. steam:		
Design, based on total steam	9.0	9.0
Actual, based on outside steam	9.0	17.9

[a] Total steam less entrained steam recovered by flashing.

Based on the stated conditions, from Figure 2 a value of 9 cubic feet of carbon dioxide per pound of steam was selected with two-stage flow for scrubbing the gas to 0.2 percent residual carbon dioxide when the partial pressure in the feed is at least 90 psi. From vapor pressure data given in earlier publications,[5,6] the pressure of the steam from the flashing of the split stream is determined to be about 9 psia, and that from the main stream 12 psia. Motive steam requirements for compressing these streams to 18 psia by the ejector are shown in Table 2. Data for ejectors are available in the literature or can be obtained specifically from suppliers.

The net steam consumption is decreased by the use of ejectors from a value of 34,700 pounds per hour required for a regeneration efficiency of 9 cubic feet of carbon dioxide per pound of steam for Case I, to a value of 17,300 pounds, giving a regeneration efficiency of 17.9 cubic feet of carbon dioxide per pound of steam for Case II. For an amine installation with a typical regeneration efficiency of 3.5 cubic feet carbon dioxide per pound steam, the steam consumption would be 89,000 pounds per hour. Thus, by using steam ejectors it is possible to decrease the already low steam consumption for a hot carbonate system to about 20 percent of that required for amine scrubbing.

Whether it is desirable to employ flash cooling in a hot carbonate installation will again depend upon the over-all situation. If a supply of low-pressure exhaust steam at pressures of 5 psig and higher (either saturated or superheated) is available and there is no other use for this steam, it will probably be more economical to use the low-pressure

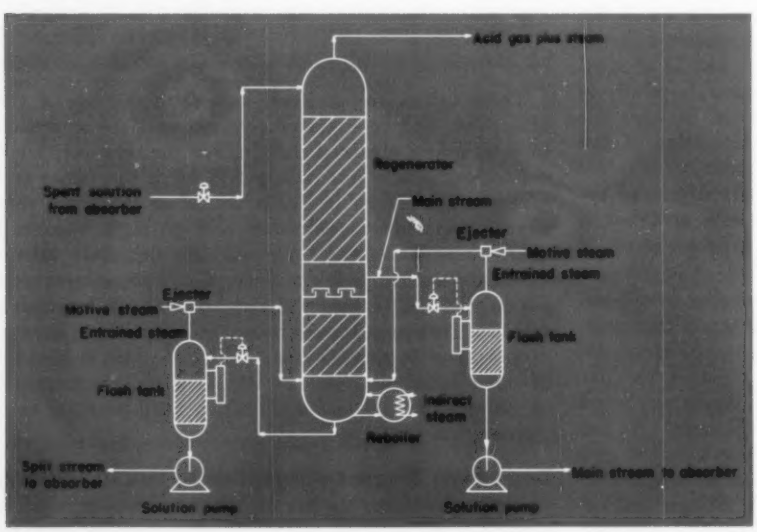

FIGURE 4—Two-stage regenerator with flash cooling by an ejector can reduce steam consumption.

TABLE 3—Pilot-Plant Experiments for Feed Gases Containing CO_2 and H_2S

Test No.	Description of Flow	Feed Gas		AT Intermediate Level[a]		Scrubbed Gas,		Soln Conc., % K_2CO_3	Entering Soln., °F.		Carrying Capacity, ft.³/gal.		Regeneration Efficiency, ft.³ Acid Gas/lb. Steam
		CO_2	H_2S	CO_2	H_2S	CO_2	H_2S		Split Stream	Main Stream	CO_2	H_2S	
114-A	Single stage, split stream	11.4	0.57	Not measured		0.60	0.019	32	206	237	3.65	0.195	6.1
126-A	2-Stage regeneration	11.4	.53	0.7	0.003	.33	.002	38	195	228	3.2	.152	6.1
127-A	2-Stage regeneration	11.2	1.05[b]	Not measured		.35	.01	32	192	226	3.1	.298	6.4
133-A1	2-Stage regeneration	11.8	5.0	0.5	0.029	.12	.025	22	197	212	1.32	.56	6.6
133-A2	2-Stage regeneration	11.5	4.4	.2	.059	.10	.01	22	161	217	1.26	.48	6.0
162-B	Single stream	0.30	0.142	.07	.00045	[c]	[c]	17	None	98	0.28	.17	..
162-C	Single stream	.32	.138	.16	.0158	[c]	[c]	17	None	192	.19	.143	..

[a] Entry point of the absorber for the main stream of solution in split-stream flow; the height of packing below this level is 24 ft.-8 in. Above this level the height of packing was 3 ft. -8 in. up to test 133, and 10 ft. thereafter.
[b] COS also removed from 13.3 grains/100 cu. ft. to zero.
[c] Main stream only; gas leaving main stream entry is scrubbed gas.

steam. This steam usually can be used directly as live steam without a reboiler, thus holding the capital investment down. On the other hand, if no exhaust steam is available and one intends to employ higher pressure steam, the use of ejectors will greatly decrease the need for the higher pressure steam. The cost of an ejector system is about equal that of the split stream cooler it replaces. Thus, the steam savings to be gained through using ejectors is not at the expense of increased capital investment. In addition, the requirement for cooling water for the split-stream cooler is eliminated, thereby making the flash cooling operation more attractive.

Natural Gas Purification by the Hot Carbonate System. Sizable natural gas reserves in the United States and Canada contain up to 30-40 percent hydrogen sulfide and carbon dioxide. The hot carbonate purification process is well suited to lower the acid gas content of such gases economically. One commercial natural gas purification plant[7] is in operation where 95 percent of the hydrogen sulfide and carbon dioxide are removed by a hot carbonate plant, and the residual acid gas is taken to pipeline purity by an amine follow-up plant. Recent pilot-plant studies by the Bureau of Mines indicate if one selects the proper operating condition, natural gas of pipeline purity ($<$ 0.25 grain hydrogen sulfide per 100 cubic feet) can be obtained with a hot carbonate scrubbing system alone.

Results of some pilot plant tests using hot carbonate solution for simultaneously removing carbon dioxide and hydrogen sulfide were reported previously.[5] Several additional experiments have been completed to determine the extent of removal of hydrogen sulfide. Some typical data are shown in Table 3. The absorption pressure was 300 psig in all these experiments. In the first five tests, the feed gas contained concentrations of about 11 percent carbon dioxide and from 0.5 to 5 percent hydrogen sulfide. The balance of the gas was nitrogen except for less than 1 percent that was hydrogen and carbon monoxide. Concentrations of carbon dioxide and hydrogen sulfide are given in Table 3 for the feed and scrubbed gases, and at the intermediate level in the absorber where the main stream of carbonate enters.

Removal of 99 to 99.8 percent of the hydrogen sulfide was achieved when two-stage regeneration, Figure 1(C), was used. In tests 114-A and 126-A, with about 0.5 percent hydrogen sulfide present, the hydrogen sulfide concentration was reduced to 0.019 and 0.002 percent when the residual content of carbon dioxide was 0.6 and 0.33 percent, respectively. Single-stage, split-stream operation was employed in test 114-A and two-stage regeneration in 126-A, with the same steam consumption in both tests. When the hydrogen sulfide content of the feed was increased to about 1 percent in experiment 127-A the hydrogen sulfide concentration in the scrubbed gas rose to 0.01 percent at essentially the same operating conditions as in 126-A. In experiment 127-A the feed gas contained 13.3 grains of carbonoxysulfide per 100 cubic feet, and this was completely removed.

A further increase in the hydrogen sulfide content of feed gas to about 5 percent was made for experiments 133-A. A more dilute solution of 22 percent concentration was used compared to the 32 to 38 percent solution in the previous tests. The principal reason for lowering the concentration was to allow use of lower temperature for the split stream without running the risk of precipitating bicarbonate. The hydrogen sulfide concentration of the scrubbed gas in test 133-A1 was 0.025 percent at a residual concentration of 0.12 percent carbon dioxide, with the split stream entering at 197° F. When the temperature of the split stream was lowered to 161° F in 133-A2, the hydrogen sulfide concentration in the scrubbed gas was reduced to 0.01 percent with other conditions maintained similar to 133-A1. When the temperature of the solution was lowered, the equilibrium pressure above the carbonate solution was reduced with a resulting decrease in the hydrogen sulfide content of the gas. At lower temperatures, the rate of hydrogen sulfide absorption remains sufficiently rapid, so there is a close approach to equilibrium as to hydrogen sulfide between the exit gas and entering solution.

To lower the concentration of hydrogen sulfide in the gas to pipe line purity, a final stage of purification was simulated in the pilot plant. A carbonate solution cooled to 90° to 100° F was used. A small part of the total solution (perhaps 2 to 5 percent) used for the bulk of the purification was required for the final stage. Cooling this small stream does not adversely affect the efficiency or steam consumption of the hot carbonate system. Tests 162-B and C show comparative results of treating a gas containing about 0.30 percent carbon dioxide and 0.14 percent hydrogen sulfide, with solutions at temperatures of 98° and 192° F. The inlet concentration of 0.14 percent hydrogen sulfide is higher than anticipated from the preceding stage of hot carbonate operation based on the results of the pilot plant. An excellent degree of purification was obtained with the solution at a temperature of 98° F, the concentration of hydrogen sulfide in the exit gas being 0.00045 percent (4.5 parts per million or less than 0.3 grain per 100 cubic feet). With the solution at a temperature of 192° F, the hydrogen sul-

fide concentration in the purified gas was 0.0158 percent.

Use of the hot carbonate system for reducing hydrogen sulfide to attain pipe line purity is feasible with high-temperature levels, near the solution boiling temperature, for the bulk of the removal, with final removal in a stage operated at lower temperature. Because the relative rate of absorption of hydrogen sulfide is 13 to 30 times that of carbon dioxide, the final removal can be achieved in a short section of a tower.

Advantage may be taken of the higher rate of absorption of carbon dioxide and hydrogen sulfide in solutions of lower concentration than the 30-40 percent solutions used in most of the pilot-plant studies. In some applications where one desires to obtain low carbon dioxide and hydrogen sulfide residual concentration in the purified gas, the split stream—Figure 1(b) (c) (d)—can be diluted with steam condensate that usually must be returned to the solution to maintain the proper concentration. This would have the advantage of increasing the rate of absorption at the top of the absorber, as well as lowering the back pressure of the acid gas from the solution.

A further means of removing the last traces of hydrogen sulfide is by using the fresh carbonate solution that is required as make-up for solution losses due to pump leakage or other handling losses. If this make-up solution is fed to a plate or two above the regenerated solution inlet, greater selectivity for hydrogen sulfide results in nearly complete removal of the small amount of residual hydrogen sulfide. Pilot-plant tests show that when the carbon dioxide and hydrogen sulfide concentration from the absorber are 0.175 and 0.0008 percent, respectively (½ grain hydrogen sulfide per 100 cubic feet), the carbon dioxide content after a further one-plate contact was 0.170 percent, and the hydrogen sulfide was reduced to 0.5 p.p.m. (0.03 grain per 100 cubic feet). This corresponds to only 3 percent removal of carbon dioxide and 94 percent removal of hydrogen sulfide. Thus, the use of fresh makeup solution, either as potassium hydroxide or potassium carbonate, fed to a top tray in the absorber acts as an additional measure to maintain the hydrogen sulfide concentration to less than pipe line purity.

Potassium dichromate, the most effective inhibitor for the carbonate system when scrubbing only carbon dioxide, cannot be used with gases containing hydrogen sulfide because the dichromate oxidizes the hydrogen sulfide, forming sulfate, thiosulfate, and some insoluble materials. However, hydrogen sulfide itself is an inhibitor when added to the carbon dioxide-carbonate system, and is effective if the raw gas contains as little as a few-hundredths of a percent of this component. All the pilot-plant tests with gases containing hydrogen sulfide were made without using an additional inhibitor. Recent laboratory tests by the Bureau of Mines indicate that additional protection from corrosion in the presence of carbon dioxide and hydrogen sulfide is obtained by using some of the commercial film-forming fatty amines.

Based on pilot plant and commercial experience, carbon steel towers and piping are satisfactory, but 300 series stainless steel (usually 316 or 304) is recommended in most cases for the solution pumps and the control valves, such as the let-down valve between the absorber and regenerator. Stainless steel generally is preferred for the reboiler tubes, although carbon steel has been satisfactory in some cases.

Conclusions. Minimum steam consumption is realized in hot carbonate purification when towers of sufficient size are provided to attain a close approach to equilibrium. Design is based on obtaining the most favorable combination of capital and operating costs. The availability and cost of steam are major factors to be considered. If the cost of steam is high and some high pressure steam is available, flash cooling, a modification of the basic hot carbonate technique, can be employed to decrease the consumption of steam. At the same time cooling of the regenerated solution is achieved.

Pilot-plant results show that the hot carbonate system is applicable for removing hydrogen sulfide either in low concentrations, as in synthesis gas, or in high concentrations, as in sour natural gas. A high degree of purity to pipe line specifications can be achieved by the use of staging.

Economic comparison of the hot carbonate system with other methods of purification have not been made here. However, the process information given, including some of the modifications to the basic system, can serve as a basis for the process engineer to evaluate the hot carbonate system for a given project and prepare cost estimates.

About the Authors

Benson

Homer E. Benson is a research engineer with Consolidated Natural Gas Company, Pittsburgh. After receiving his B.S. degree in chemical engineering from Case Institute of Technology in 1941, he went to work for the Bureau of Mines, where he developed processes to make synthetic oil and gas from coal by the Fischer-Tropsch route. He was Chief, Gas Synthesis Section, Region V, Bureau of Mines, at the time he developed gas purification processes leading to the hot carbonate process. He went to Consolidated in 1958.

Field

Joseph H. Field succeeded Benson to the post of Chief, Gas Synthesis Section, Bureau of Mines in 1958. After receiving a B.S. degree in chemical engineering from Carnegie Institute of Technology, Field went to work for the Bureau in 1941. Except for two years in the Navy, he has spent his career with Bureau in process development. He received an M.S. degree in chemical engineering from the University of Pittsburgh in 1944.

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A SPECIAL REPORT

OPERATOR'S HANDBOOK FOR GASOLINE PLANTS

Part 8 – Orifice meters: One of a series that simplifies operations and equipment for the new and experienced operator in a natural gasoline plant

Manufacturing Department, Tennessee Oil Refining Co.
A Division of Tennessee Gas Transmission Co., Houston

OPERATORS have more contact with the orifice meter than any other instrument in a natural gasoline plant. Flow rate is one of the most important measurements watched by the operator. So, this section has been singled out from Part 3 on instruments for special understanding.

The basis for this measurement is the relation between the rate of flow of a fluid and its loss in pressure in flowing through a restriction in the line of flow. In more precise terms, we know that the pressure loss caused by a restriction is proportional to the square of the velocity of the fluid. The venturi tube and flow nozzle, as well as the orifice plate, use this principle to measure flow.

Figure 1 shows a conventional venturi tube, as used by industry today. The venturi tube has lost out in popularity in the gas industry but is still employed by refinery, chemical and other industrial users, where a minimum permanent pressure loss is desirable. Venturi tubes are also employed when the flowing fluid contains considerable solids and other material which might conceivably be abrasive in nature. Viscous fluids are sometimes measured by means of the venturi tube.

The flow nozzle is a venturi throat without the tail section. It is similar in performance to the venturi throat, but shorter in length.

The sharp edged orifice plate, shown in Figure 1, has become the most widely accepted of all the primary differential measurement devices, because it is most practical, easiest to duplicate, and most economical to produce. Today, in the production, transportation and distribution of natural gas, the use of the flat, sharp edged orifice plate is almost universal, particularly where flow rates are extremely large.

An accepted standard (American Gas Association Report No. 3) specifies that the upstream face of the orifice plate shall be as flat as is commercially obtainable and that the upstream edge of the orifice should be sharp and square and not reflect a beam of light when viewed without magnification.

It is general practice to employ a ⅛-inch thick orifice plate, although ¼-inch thick plates are used in large-sized lines and in some of the very large-diameter lines, such as 30-inch, plates as thick as ½-inch have been employed. Important points to remember with reference to the orifice plate, are that it should be bored accurately with a sharp upstream orifice, and that it should be flat and polished to eliminate blemishes and scratches.

Pipe vs. Flange Taps. In Figure 1, it will be noted that as the stream approaches the orifice it tends to converge in order to pass through the orifice. The approach velocity, and the velocity component which is set up due to the change in direction at the plate, produce a section just beyond the plate called the *vena contracta*. This is the smallest diameter of the flow stream. As can be seen in the illustration, beyond this point the stream gradually expands until it again fills the entire pipe section.

In Figure 2 the maximum differential (h) set up by the orifice plate occurs with flange taps or throat taps, whereas the pipe taps are functions of the permanent pressure loss in the system.

The restoration of pressure with the sharp edged orifice in Figure 2 is considerably lower than the pressure recovery obtained by the venturi in Figure 1. This is due primarily to the energy which is lost in turbulence

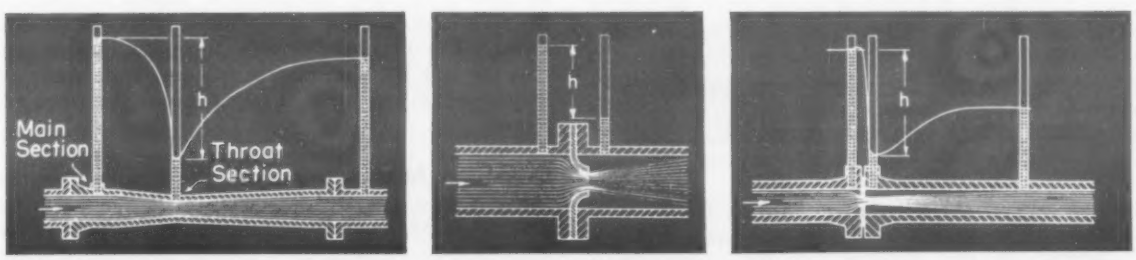

FIGURE 1—Comparison of the venturi tube, flow nozzle and flat orifice shows different pressure drops and pressure recoveries.

forming the *vena contracta* section. That energy loss is permanent. The explanation of this primary disadvantage of the flat orifice plate is that it does not have the smooth approach and exit contours of the venturi tube and the pressure recovery is rarely more than 60 percent of the total pressure drop at the plate. Under most measurement conditions, however, this pressure loss is usually a very small part of the total pressure involved and is generally inconsequential.

Typical Installation. Figure 3 shows a schematic diagram of a typical orifice meter installation. The gauge lines are shown connected to the flange taps, since this is the most widely used method in the industry today. The basis for the orifice meter assembly is a restriction which creates a resistance to flow and a differential gauge or manometer which measures the drop in pressure which is produced. In purpose the orifice plate, which is the restriction, is no different from a pinched valve.

Referring to Figure 3 again, if a valve was placed in the line instead of the orifice as shown, and the valve was gradually pinched, the upstream pressure (P_1) would gradually increase and at the same time the downstream pressure (P_2) would decrease. At each valve setting or position, a certain ratio between P_1 and P_2 would exist. This difference in pressure is recorded by the orifice meter by means of the float assembly and a calibrated linkage between the float and the differential pen.

For instance, as P_1 increases, it forces the level of the mercury down in the high pressure chamber through the U-tube, while the decrease in P_2 allows the mercury level to rise in the low pressure chamber. The float rides on the surface of the mercury, as shown in the diagram, and this vertical movement is calibrated to record inches of water on the orifice meter chart. The float assembly is connected by a linkage arm directly to the shaft on which the differential pen is connected.

The orifice plate is chosen to create a pressure drop within allowable limits. There exists calibration data or coefficients for this orifice plate size which are used in determining the quantity of gas passing at any given differential pressure.

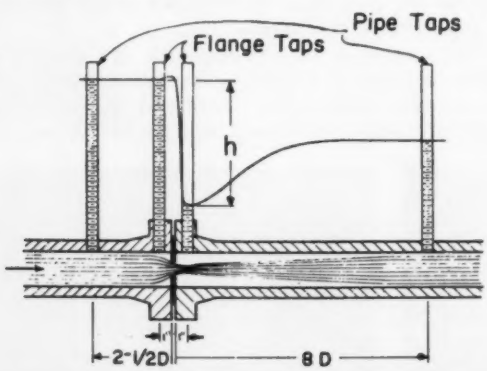

FIGURE 2—Flange taps show more pressure differential (h) than pipe taps. Pipe taps measure the permanent pressure loss.

MEANING OF TERMS IN GAS FLOW FORMULA

Gas Flow Formula. Putting mathematics aside, it's helpful to understand the derived formula as given in American Gas Association Gas Measurement Committee Report No. 3. It states, in the form of equations, that the rate of flow in cubic feet per hour is equal to a basic orifice flow factor times a Reynolds number factor times an expansion factor times a pressure base factor times a temperature base factor times a flowing temperature factor times a specific gravity factor times a super-compressibility factor times a manometer factor times the square root of the differential pressure in inches of water times the static pressure in pounds per square inch absolute.

The formula substitutes letters for these various quantities as follows:

$$Q_h = F_b \times F_r \times Y \times F_{pb} \times F_{tb} \times F_{tf} \times F_g \times F_{pv} \times F_m \times \sqrt{hp}$$

This is nothing more nor less than mathematical shorthand to reduce the space required for writing the formula. The quantity rate of flow in cubic feet per hour is represented by the term Q_h which may be remembered as "the quantity per hour."

Flow Factor. The basic orifice flow factor is represented by the term F_b. This term in the equation takes care of a great many effects, the most important one being that of orifice diameter. It includes all of the constants necessary for converting the basic equation into the commercial formula. It includes an experimentally determined correction for the effect of pipe size on the flow coefficient and for the location of the pressure taps. It was found that this factor was, to some extent, dependent upon certain characteristics of the meter installation, and for orifice thickness, sharpness, length of approach pipe, etc. We shall go into this in greater detail further on.

Reynolds Number. The next term in the equation is the Reynolds number factor F_r. Now if smoke is injected into gas flowing in a glass pipe line, we find that the smoke does not flow through the pipe in the form of a block. The smoke in the center of the pipe is flowing at an appreciably higher velocity than that which is adjacent to the pipe wall and is held back by friction. Similarly at ordinary gas velocities, the gas in the center of the pipe is flowing from 15 to 25 percent faster than the average. At extremely low velocities it becomes as much as twice the average rate. In passing through the orifice, the situation is further complicated by a change in the amount of contraction of the jet at the *vena contracta*.

The combined effect of these phenomena is found to be related not alone to velocity or density or viscosity, but to a dimensionless ratio of these factors in what is called a Reynolds number. The Reynolds number governs the type of flow; that is, whether it is viscous or nonviscous or just where it falls between these two extremes.

Expansion Factor. This factor, Y, is a term in the equation which is necessary only in the case of compressible fluids. It does not appear in the liquid flow formula because, with most liquids, the density is the same either side of the orifice plate. The hydraulic

formula, as the name indicates, was developed for liquids.

In the case of flow nozzles and Venturi tubes, a more accurate analysis can be made using the laws of adiabatic expansion to determine the proper density to use in the flow equation. In the case of orifices, another consideration complicates the situation: the jet issuing from the orifice is not confined, as in the case of the flow nozzle or the Venturi tube, and therefore is free to expand at the reduced pressure. The over-all effect of these phenomena for given orifice installation are covered by the factor Y which bears a relation to the ratio of differential to absolute static pressure and to the expansion characteristics of the gas as defined by the ratio of specific heats.

Pressure and Temperature Base Factor. The pressure base factor F_{pb} is not peculiar to orifice measurement; likewise, the temperature base factor F_{tb}. They are necessary for any form of gas measurement whether it be by orifice meter, displacement meter or gas holder. They are the factors by which the volume is reduced to some agreed-upon condition of storage temperature and pressure.

Flowing Temperature. This is the temperature at which the gas is actually flowing through the meter run. It is usually obtained direct from a temperature recorder placed next to the orifice meter. The factor F_{tf} is determined to correct the gas volume from the flowing temperature to the base temperature.

Specific Gravity. This factor is the ratio of the density of the gas to that of air, with the density of air being 1.00. The specific gravity factor F_g is used to correct the volume of gas for varying specific gravities.

It will be found in the flow equation that a number of factors have a bearing on the density of the gas as it flows through the orifice. These factors are only necessary because there is no method of determining the density of the gas flowing through the orifice. This density is calculated from the flowing temperature, flowing pressure, supercompressibility and specific gravity. In the steam flow formula the density of the steam is used directly in the equation and the terms for flowing temperature, specific gravity, supercompressibility and static pressure are absent. All factors having to do with density occur as square-roots. If it were possible to measure the density of the flowing gas at flowing conditions, directly, the static pressure, flowing temperature, and supercompressibility factor would be replaced by a single factor. If, furthermore, the measurement was in weight units rather than volume, an additional three factors: specific gravity, pressure base, and temperature base would drop out, leaving quite a simple formula.

Supercompressibility. This factor F_{pv} accounts for the deviation from the perfect gas laws. In the basic flow equations, gas volumes are assumed to vary with pressure and temperature in accordance with Boyle's and Charles' laws (the perfect gas laws). Actually the volume occupied by individual gases deviate, by a slight degree, from the volumes which the perfect gas laws indicate. The amount of deviation is a function of the composition of the gas and varies primarily with static pressure and temperature. The actual deviation is obtained by a test conducted on a sample of the gas, carefully taken at line conditions of pressure and temperature.

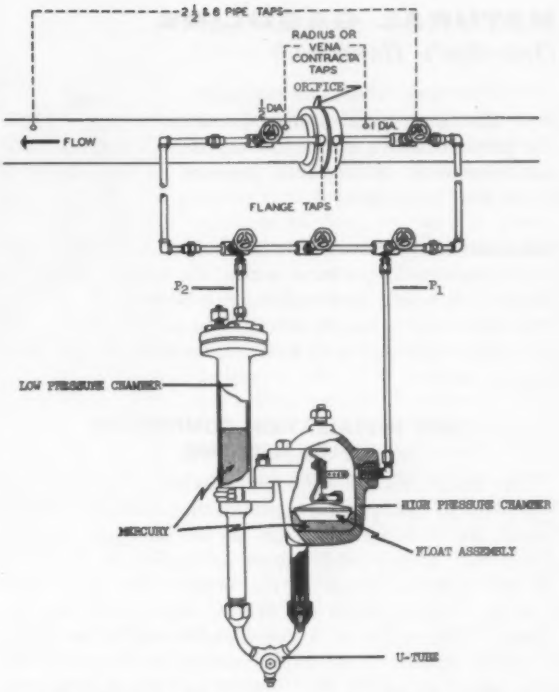

FIGURE 3—A typical orifice meter installation, showing flange taps connected by gage lines to U-tube manometer.

Practical relationships have been established by which this deviation can be calculated and tabulated for natural gases containing normal mixtures of hydrocarbon components, considering the presence of small quantities of carbon dioxide and nitrogen and also relating the deviation to the heating value of the gas.

Manometer Factor. AGA Report No. 3 brings in a new factor which has become important due to numerous operations involving measurement of high-pressure gas. This is the manometer factor F_m. It is difficult to visualize gas as having appreciable weight, but at high pressures it is not at all uncommon for dry natural gas to be more than one tenth as heavy as water.

Now visualize an orifice installation with a mercury U gauge, measuring the differential, located a few feet below the flange. If there is a 100″ differential at the level of the flange taps, there will be slightly more than 100″ at the level of the mercury in the manometer, because the displacement of the mercury has caused the column of dense gas to lengthen on the high-pressure side and shorten on the low pressure side. This is the effect for which the manometer factor compensates. The effect is the same whether a mercury manometer or a mercury float type meter is used, and is the same whether the meter is located below or above the orifice plate. The amount of the correction is small.

Static Pressure. This is the actual flowing pressure on the meter run, usually measured in pounds per square inch gage. It may be taken from either the upstream or downstream pressure tap, but common practice is to

have the connection on the downstream tap. This is the pressure above (or below in case of measurement under vacuum) atmospheric pressure. It is represented in the flow formula as P.

Differential Pressure. As the name indicates, it is the difference in pressure across the orifice plate. In Figure 3, it would be the difference between P_1 and P_2. This difference is usually recorded in inches of water on the orifice meter chart. It is represented in the flow formula as h.

WHY INSTALLATION CONDITIONS AFFECT METERING

The basic orifice flow factor included in the equation is dependent upon certain installation conditions. It was found, for instance, that this factor increased considerably with a very small amount of dulling or rounding on the upstream edge of the orifice. The gas, compressing to go through the orifice, must strike the upstream orifice edge at a considerable angle. Actually, it would appear from experimental results as if the only point at which the flowing gas struck the thin sharp edged orifice was the upstream edge.

The increase in the coefficient is almost exactly proportional to the increase in the diameter of the hole at the upstream face of the plate. 1 percent rounding increases the area at this point by approximately 2 percent and that is the amount of the increase in the coefficient. The specifications therefore require that the upstream edge of the orifice shall be square and sharp so that it will not appreciably reflect a beam of light when viewed without magnification. The accumulation of dirt has an effect equivalent to rounding the edge, so the plate should also be kept clean at all times.

Obviously a plate cannot be bent or bowed without stretching the hole on one face and compressing it on the other. On the concave side, the bent orifice approaches the shape of a beveled orifice. Bending also changes the location of the pressure taps with respect to the orifice face when the orifice is clamped between the flanges. Specifications now rule that the orifice plate, when clamped between the flanges, should not depart from flatness along any diameter by more than 1/100th of an inch per inch of pipe radius.

Thickness. The effect of orifice thickness is a little more difficult to visualize. One would normally expect the thick orifice to further interfere with the free flow of gas and therefore cause the coefficient to be low, but the reverse is actually the case. Tests indicate that in order to be unaffected by thickness, the orifice plate should be less than ⅛ of the orifice diameter, less than 1/30 of the pipe diameter and less than ¼ of the dam height or the projection of the orifice into the pipe. The dam height is equal to the radius of the pipe minus the radius of the orifice bore.

In some cases it may be necessary to make the orifice thicker than these specifications to provide the necessary resistance to bending when the differential pressure is applied. In such cases, the downstream face may be beveled or recessed at an angle of not more than 45 degrees to the face of the plate and to a depth sufficient that the cylindrical portion of the hole does not exceed the specified thickness.

The location of the vena contracta is governed by the upstream face of the orifice plate, but the location of the downstream tap is governed by the downstream face of the plate. Therefore, too great a thickness would seriously affect the downstream pressure tap location. For that reason, it was specified that the orifice plate thickness should not exceed ¼ of an inch or be less than ⅛ of an inch.

Pressure Taps. When the jet of gas leaves the orifice, it continues to contract for a short distance and then starts to expand. Corresponding to this contraction and expansion there is a gradual decrease in pressure for a short distance downstream from the orifice and then a sharp increase. If the pressure tap hole is excessive in diameter, it may be subject to one pressure at the side adjacent to the orifice and an entirely different pressure at the other side. A difference in pressure such as this cannot occur without motion (usually from the region of higher pressure to that of lower pressure) and the result is bound to be a region of excessive turbulence. For that reason, the pressure tap hole was limited to a diameter not to exceed ⅛ the diameter of the pipe in sizes from 2 inch to 4 inch and not to exceed ½ inch in the larger sizes. Excessive tap diameter results in a low coefficient or a high meter reading.

Burrs or irregularities around the pressure tap hole create suction or impact effects. Just as the curved upper surface of an airplane wing creates a suction sufficient to lift the plane, a burr or a chip at the edge of the pressure tap hole may create a suction effect causing the meter to read high or low. Therefore the pressure tap hole edges should be carefully cleaned and slightly rounded.

In the early days when cast iron orifice flange unions were widely used, it was common practice to end the pipe an inch and a half or two inches back of the face of the orifice and to core out a large recess into which the pressure hole was drilled. This made it unnecessary to drill through the pipe in order to connect out the meter. On establishing more accurate coefficient data is was suspected that the variation in this recess between various manufacturer's designs would make it impossible to establish accurate coefficient data. Therefore, tests were run on flanges of these types and errors as high as 7 percent were found. It was established, however, that a ¼ inch recess for welding could be allowed without an appreciable effect on the meter reading.

Approach. The pipe used on a meter run should be chosen with great care, particularly the approach pipe. It should be commercially smooth, uniform in bore, and accurate to dimensions. The higher the d/D ratio (orifice diameter to pipe diameter), the greater accuracy of dimensions required. It is customary to apply the tolerances necessary for the maximum d/D which may be used in the setting. Greater accuracy of dimensions is required with pipe taps than with flange taps.

Flow measurement may be affected by fittings or combinations of fittings more than forty pipe diameters upstream from the plate. Fittings which tend to create

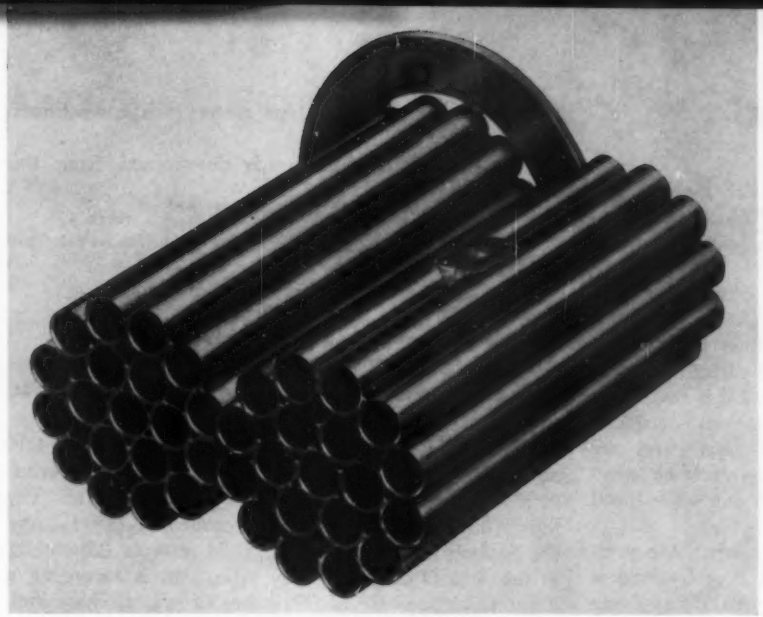

FIGURE 4—Straightening vanes within the pipe can eliminate swirls in stream. Left is ring-mounted; right, pin mounted.

a vortex are particularly troublesome. These swirls normally carry downstream for great distances, but fortunately they can be eliminated in a very short space by use of straightening vanes. Straightening vanes for gas measurement are usually constructed of bundles of tubing welded together in the form of a honeycomb and inserted in the line 6 to 8 pipe diameters upstream from the orifice, as shown in Figure 4. The length of the vane should be at least 10 times the maximum diameter of any of the tubes or the width of any aperture between tubes or partitions. It is the purpose of these vanes to straighten out the flow of gas so that smooth laminar flow may be obtained before it reaches the orifice plate.

Principle of Liquid Measurement. In measuring liquids, as contrasted to gases, with the orifice meter, there are several modifications and changes which must be made in the general equation of flow. In the first place, the entire matter is simplified by the fact that there is no important effect of static pressure variation in the case of liquids. No account, therefore, must be taken of variation in density as the fluid passes through the orifice section. This also simplifies the calculation of the coefficient, since no base pressure correction is required, and no correction factor is needeed for expansion due to change of pressure. In making the record on the meter chart, the static pressure system and pen are not used since they are not necessary.

The simplification resulting from the elimination of static pressure records is more than counterbalanced by the complications introduced by the viscosity of the liquids. The variation in viscosity in the liquids usually commercially measured with the orifice meter causes complications in determining the orifice coefficient. Water in the temperature ranges usually encountered has a viscosity sufficiently constant so that this factor offers no concern, and accurate measurement of flowing water with the orifice meter is common. Crude oil, petroleum products and similar liquids, however, are of such a nature that the variation in viscosity makes it

Example Calculations for Gas Flow

An orifice meter records a static pressure of 1,000 pounds per square inch and a differential pressure of 52 inches of water. The meter run is 4-inch OD pipe and has a 1.25-inch orifice plate installed. The temperature recorder indicates a flowing temperature of 70° F., and the specific gravity of the gas is known to be 0.656. The base pressure and temperature are 14.65 psia and 60° F., respectively. The Reynolds Number Factor and Expansion Factor will be assumed to be 1.00 to eliminate lengthy mathematical calculations. (Actually, many gas contracts are written with these numbers specified as being equal to 1.000). The procedure for calculating the volume of gas flowing through the orifice is:

Summary Of Conditions

Static Pressure = P = 1,000 pounds per square inch gauge
Differential Pressure = h = 52 inches of Water
Flowing Temperature = F_{tf} = 70° F.
Specific Gravity of Gas = .656
Base Pressure = 14.65 pounds per square inch absolute
Base Temperature = 60° F.
Meter Run Diameter = 4.026 inches
Orifice Diameter = 1.250 inches
Meter Gage Lines Connected to Flange Taps

From Table 3 in The American Gas Association Committee Report Number 3, we find that with a 4.026-inch pipe diameter, and a 1.250-inch orifice diameter, the basic orifice factor $F_b = 317.45$.

From Table 12 of AGA Report No. 3, the correction factor for a pressure base of 14.65 psia is 1.0055, which is F_{pb}.

From Table 13 the base temperature factor (F_{tb}) is found to be 1.000.

From Table 14, the flowing temperature factor (F_{tf}) is found to be 0.9905.

From Table 15, the specific gravity correction factor (F_g) is found to be 1.2347.

The supercompressibility factor is dependent upon the static pressure, flowing temperature, and specific gravity of the gas. Tables have been prepared from numerous laboratory tests on the compressibility of various gases and Table 16-A is an example for gas with a specific gravity of 0.600. For the gas under consideration (specific gravity = 0.656) the factor F_{pv} is 1.0929.

From Table 17, the monometer factor F_m is found to be 0.9974.

The differential pressure was recorded on the meter as 52 inches of water.

The static pressure of 1,000 lbs. per square inch gauge is converted to absolute pressure by adding the pressure base (14.65 pounds per square inch) to obtain an absolute static pressure of 1014.65 psi.

By substituting all the above factors into the flow formula, the quantity of gas flowing per hour is obtained.

$$Q_h = 317.45 \times 1 \times 1 \times 1.005 \times 0.9905 \times 1.2347 \times 1.0929 \times 0.9974 \times \sqrt{52} \times 1014.65$$

Q_h = 97,742 cubic feet of gas per hour.

rather difficult to arrive at an accurate coefficient. The amount of experimental work done, while quite extensive, has not been correlated and coordinated to the extent it has been with gas.

Another factor which causes some difficulty in the measurement of crude oil is the amount of dissolved gases and free gases in the fluid. These gases affect viscosity to some extent, but their chief difficulty is that they affect actual oil volume when the oil is finally reduced to atmospheric pressure. When the oil is reduced to atmospheric pressure and the dissolved gases are freed, the resulting oil volume shrinkage must be taken into account so the volume as metered can be reduced to volume at atmospheric pressure.

With the exception of the static pressure, base pressure, and expansion factor, the liquid flow formula is essentially the same as the gas flow formula. By applying necessary volume and density conversions in the form of a gravity-temperature factor F_{gt}, it is possible to use the basic gas orifice factors F_b for the measurement of liquids. With a mercury type meter, a correction factor must be applied for the unbalanced head of liquid, of flowing gravity, in the manometer. This is usually included in the gravity-temperature factor F_{gt} for this type meter. For bellows type meters this correction is not necessary.

The rate of liquid flow is determined from this formula:

$$Q_h = F_b \times F_{gt} \times F_{sl} \times F_r \times \sqrt{h} \quad \text{where}$$

Q_h = Quantity of liquid passing the orifice in gals/hour
F_b = Basic orifice factor
F_{gt} = Specific gravity-temperature factor
F_{sl} = Factor for seals (if required)
F_r = Reynolds' number, "viscosity" factor
h = differential pressure in inches of water

This example will illustrate the method of calculating the liquid rate of flow at the given conditions.

EXAMPLE: A liquid with a specific gravity of 1.10 at 60° F. is flowing through a 1.00 inch orifice installed in a meter tube with a diameter of 3.068 inches. The liquid flowing temperature is recorded at 60° F., and the Saybolt viscosity at 60° F. is 34 seconds. The meter in use is a 50-inch mercury type, and is recording a differential pressure of 30 inches of water. Four inch seals are in use and the sealing fluid has a specific gravity of 0.87.

SOLUTION: From tables available in any orifice meter handbook we find that the basic orifice factor for a 3.026" pipe and a 1.00" orifice is 203.54. The gravity-temperature factor is 0.9193. The factor for seals is 1.0055. The Reynolds' number factor is 1.015.

By substituting the above values in the flow formula, the rate of flow is obtained.

$$Q_h = 203.54 \times 0.9193 \times 1.0055 \times 1.015 \times \sqrt{30}$$

$$Q_h = 1050.5 \text{ gallons per hour}$$

These calculations illustrate the complete or long method of obtaining liquid rates of flow through orifice meters. These calculations can be greatly simplified in some plant operations by combining all the factors such as F_b, F_{gt}, F_{sl}, and F_r into one constant, and using direct reading charts which record the square root of the differential pressure. This is commonly referred to as roots. For instance, instead of the meter recording 30 inches of water on a regular chart in our example, it would record 5.5 roots on a square root chart. The combined factor in the example is 191. The only calculation necessary to get the rate of flow is to multiply 191×5.5 and get the rate of flow = 1050.5 gallons per hour.

In conclusion, it should be pointed out that the orifice meter is a precision instrument, yet it is simple, rugged, and easy to maintain. With only a reasonable amount of care and maintenance, a high degree of accuracy can be obtained indefinitely. An orifice meter, however, is only as accurate as the orifice allows it to be. As pointed out early in this section, the condition of the orifice plate is very important. For this reason, a regular inspection program should be set up to examine the orifice plates in use. If they become dull, buckled, or nicked they should be replaced. The type of service would govern the inspection period, but orifice plates should be inspected at least semiannually. Where senior type orifice fittings are used, the plates should be inspected monthly. This not only aids in maintaining clean, sharp plates, but also prevents the pinion gear on the orifice fitting from freezing or sticking so tightly that it cannot be operated.

(TO BE CONTINUED)

Many Authors Behind This Series

Pearce

The "Operator's Handbook for Gasoline Plants" was prepared by the manufacturing department of Tennessee Oil Refining Company under direction of **Kenneth G. Pearce,** vice president. This company, formerly named Bay Petroleum, is a major operating division conducting the refined products manufacturing and marketing business of Tennessee Gas Transmission Company.

Pearce, after graduating from the U. S. Naval Academy, joined The Carter Oil Company in the Gasoline Department in 1934. Naval service during World War II interrupted his career, but he returned to Carter after the war. He joined Creole Petroleum Corporation in Venezuela as a gasoline superintendent in 1947. Before coming to TGT as gasoline superintendent in 1954, he was assistant manager of McKamie Gas Cleaning Company for two years. He was made a Bay Petroleum vice president in 1959.

Other contributors to this handbook in the manufacturing department include **K. O. Stowell,** technical assistant, Houston; **B. M. Withers,** senior plant engineer, Houston; **P. R. Godshalk,** plant engineer, Houston; **Clyde P. Brown,** plant superintendent, Eagle Lake, Texas; **W. L. Coffey,** plant superintendent, Agua Dulce, Texas; **T. F. Hayes,** plant superintendent, La Porte, Texas; **Guy Sutherland,** assistant plant superintendent, La Porte; **L. M. Choate,** chief clerk, Houston and **W. G. Pullin,** plant tester, La Porte, Texas.

Contributors from other divisions and departments of Tennessee Gas include **Ray Garrigus,** safety manager; **Mack Duncan,** electrical engineer; **Art Rutrough,** training supervisor; **Lee Mitchell,** assistant office manager, and **Warren D. Boozer,** buyer.

A SPECIAL REPORT

BETTER STEAM BOILER MAINTENANCE

Only a modern maintenance program can capitalize on today's steam boiler efficiency

Elmer Mason
Phillips Petroleum Company, Phillips, Texas

TODAY'S STEAM BOILERS with improved design and efficiency require additional maintenance to keep up with modern complexity and controls. Here's a practical guide to cleaning, repair and preventive maintenance.

To realize the gains in boiler efficiency, we must have a preventive maintenance program which will insure optimum operating efficiency consistent with safety and lowest maintenance costs. Inspection and records are recognized as one of our best tools for preventive maintenance; preventive maintenance in turn is designed to prevent more costly repairs by recognizing through inspection records and past operating experience, possible points of failure in the boiler or appurtenances and making necessary repairs at scheduled shutdowns.

Inspection by company personnel should supplement the insurance or state inspector's by providing operating and maintenance sections with more detailed reports of equipment condition, and suggestions or recommendations for changes or repairs. A review of past inspection records and maintenance reports will be found invaluable in determining the scope of future maintenance requirements.

A standard maintenance procedure cannot be made

SAMPLE

BOILER MAINTENANCE REPORT

This report is to be made out for each boiler at the completion of the necessary work at each scheduled shutdown. Any work which was done between scheduled shutdown periods should be shown on the report with the date of such repairs, the material used, etc. If new tubes have been installed, identify the position of the tubes.

Explain action taken on the following items such as repaired, cleaned, replaced, or OK.

Date 11-20-59 Boiler No. 1 (Plant) Plant

1. Tubes Turbined all tubes and cleaned drums
   Tested with 1000# CWP: All tubes were tight
2. Steam valves Repaired and cleaned steam non-return valve
3. Feed water regulator valves, lines Cleaned regulator valve:
   Lines were clear
4. Water column and lines Column and lines checked: were OK
5. Safety valves Checked prior to shutdown - were OK
6. Steam gage Dead weight tested - this shutdown
7. Blow-off valves and lines Remacked 2nd valve: lines OK
8. Feed water lines Lines are scaling slightly - OK at this time
9. Feed water spreader Cleaned
10. Burners Orifices cleaned
11. Firebox setting and baffles Good condition
    No repairs necessary
12. Remarks: Inspected by insurance and company inspector - No recommendations

By N.L.B.

cc: District Superintendent
Plant

FIGURE 1—A sample boiler maintenance form makes it easy to record what was done at scheduled shutdown.

SAMPLE

External Boiler Inspection
File:

Plant Boiler No. & State No.

1 - 30921
2 - 30922
3 - 30923
4 - 30924

Dear Sir:

The boilers at _____ plant were inspected externally on _____ while in operation under a steam pressure of _____ psi.

The following items were checked:

1. Safety Valves: Correctly set and sealed; not leaking.
2. Water Columns & Gauge Glass: Drained and found to be clear.
3. Low Water Alarm: Water column whistles and magnetrol alarms operated OK.
4. Blow Off Valves: Valves operated freely; lines were clear.
5. Steam Gauges: Compared with test gauge; found to be correct.
6. Lines & Fittings: Sound and tight except as noted in remarks.
7. Remarks: No. 2 boiler - Gasket leak at flange in blow-down line between boiler and first valve; to be repaired at scheduled shutdown.

   Tubes and furnace section appeared satisfactory as could be seen through furnace peep-holes. Structural setting and general external condition of boilers was good.

Very truly yours,

FIGURE 2—The external boiler inspection report can be standardized like this letter form.

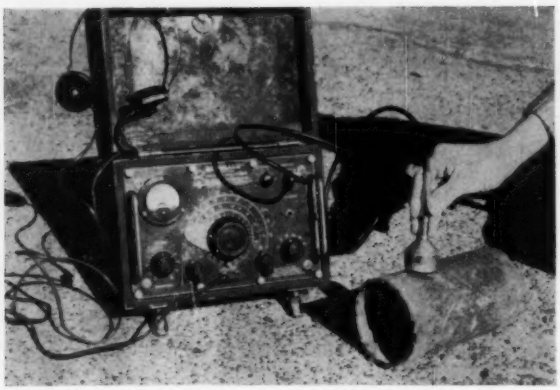

FIGURE 3—This portable resonance unit is the common instrument for checking tube and plate thickness.

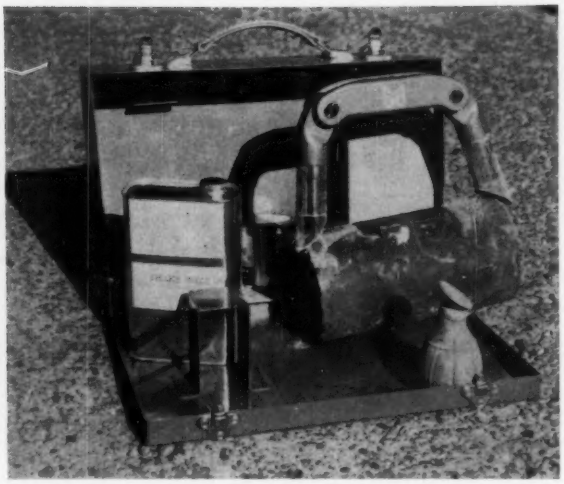

FIGURE 4—This magnetic-particle inspection kit is used to detect cracks and flaws at tube or plate surfaces.

applicable to all boilers except in a general way. The maintenance requirements of identical boilers located at different plants will be affected according to the effectiveness of feed water treating facilities, required firing rate to meet plant steam demands and of course the human element—the operator.

CLEANING AND REPAIR

To reduce unscheduled boiler outage because of faulty equipment which might have been checked, cleaned or repaired during scheduled boiler shutdowns, a general outline for cleaning and maintenance procedures can be used as a guide and modified as found necessary after sufficient records have been compiled to point out the particular parts of the boiler or auxiliary equipment which should be given special attention at six months, one-year or two-year intervals. This cleaning and maintenance procedure will differ only as to method of cleaning fire tube and water tube boilers and extra equipment on boilers using other than natural draft.

1. Cleaning Tubes

(a) **Water tubes (bent tube, sectional and box header types).** Any leaking tubes should be tightened by rolling, and all salt deposits formed around the tubes and on the drums should be removed. Scaled tubes should be turbined slowly enough and the turbine run through the tubes as many times as necessary to remove all the scale which can be removed by the turbine. Care should be taken that the turbine is not held in one spot causing the cutter wheels on the cleaner to score the tube wall. All loose salt and ash deposits which have accumulated on the outside of the tube and which can be reached should be cleaned off. If the boiler is to be out of service for several days, this salt and ash deposit can usually be easily removed by spraying the tubes with water. This should not be done unless sufficient time is allowed for drying out the brick in the firebox. Six to eight hours after the washing, a light fire should be started and the furnace allowed to dry for approximately twelve hours before raising the firing rate and putting the boiler back in service. With certain types of boilers where the extra length and bends in the tubes makes it impractical to mechanically clean the boilers, acidizing is used.

(b) **Fire tubes (locomotive firebox and horizontal return tubular types).** Where excessive scale has accumulated on the water (external) side of the tubes, a knocker or vibrator type of cleaner should be used to remove, or loosen the scale so that the water treatment will be more effective. Heavy scale accumulations between the tubes, particularly next to be firebox tube sheet, should be cleaned by rodding between the tubes. The fire (internal) side of the tubes should be brushed to remove ash and soot deposits.

2. Cleaning Drums and Shell Plates

(a) **Water tube boilers.** With present day feed water treatment, very little scale deposits on the drums; where the scale has built up as much as ⅛" thick, the scale should be removed by the use of a pneumatic descaling tool or a scraper.

(b) **Fire tube boilers.** Particular attention should be given to scale deposits on the crown sheet of locomotive type boilers and the bottom shell plates of HRT boilers. A heavy deposit on these plates will cause overheating of the metal and bulging or possible failure of the plates. Heavy scale deposits should be removed from other water surfaces of the plates as permitted by the tubes and stays.

3. Feed Water Regulator Valves

These should be dismantled as necessary to clean, repair or replace parts; in some cases where unusual scale conditions are encountered the cleaning period

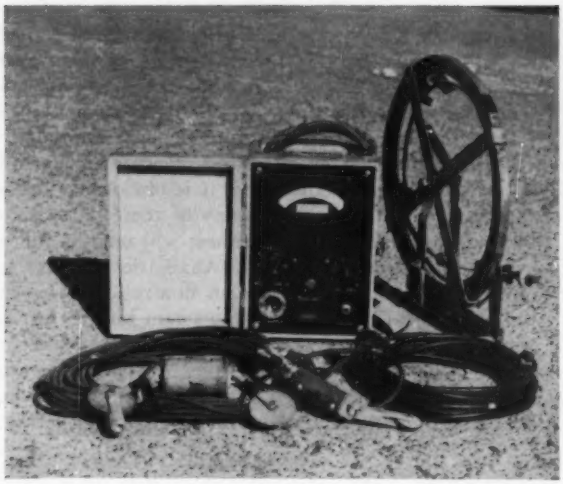

FIGURE 5—This internal boiler tube scale thickness indicator can also be used to check cleaning effectiveness.

of the valve should be as often as necessary to provide trouble free operation.

4. Automatic Steam Valve

The automatic steam valve should be cleaned as often as found necessary to assure the proper operation of the safety features for which the value was designed. This of course will depend on the quality and cleanliness of the steam and can only be determined by yearly inspections until the longest safe operating period is determined. When found necessary the valve should be dismantled so that all parts can be thoroughly descaled, the seat re-ground and the worn parts replaced. When a triple acting valve is used, the weight loaded pilot valve should be checked carefully for line leaks and proper seating of the pilot valve seat. Leakage in the connecting lines or under the pilot valve seat can cause a triple acting valve to shut the boiler in under any steam load.

5. Water Columns

The water column should be thoroughly cleaned at each yearly scheduled shutdown. The top should be removed, the float and operating parts carefully examined for wear. The Hi-Lo alarm and connecting parts should be examined for fine particles of scale. The plugs in the four way tees of the column lines should be removed and the lines cleaned.

6. Safety Valves

The safety valves should be tested by making an accumulation test on the boiler prior to the boiler's scheduled shutdown; by following this procedure, valves which are found to operate improperly by sticking, leaking or failure to pop within the code tolerances may be shopped or replaced during the boiler shutdown period. Discharge pipes should be raised to proper heights above the valves and clamped securely to building or braces to prevent weight of pipe from resting on the valves. Drip-pan elbows should be cleaned of loose scale and the drains examined to be sure they are open.

7. Blow-Off Valves

The blow-off valves should be carefully checked while the boiler is in operation so that worn valves or leaks at the valve packing gland may be properly repaired at the scheduled shutdown.

8. Steam Gages

The steam pressure gage should be dead-weight tested or compared with a test gage at least once each year and corrected or replaced as necessary and the test date marked on the gage face. Steam gage lines smaller than ½-inch should be blown out at least once each year to be sure they are free from deposits.

9. Drum Internals

(Feed water spreader, steam separator or dry pipe, continuous blow-down header.) Internal piping in the steam drum should be dismantled as far as required to be sure that lines are free from scale and sludge deposits.

10. Lines, Valves and Fittings

All lines to be checked as far as possible for scale, thinned sections and leaks. Careful attention should be given to see that all lines are properly supported and free to expand. Valves and fittings to be checked for leaks at threaded connections and packing glands. Repairs or replacements to be made as necessary.

11. Tube Repairs

Any work requiring rolling of tubes or tube replacements should be performed, if at all possible, by an experienced boilermaker. Inexperienced labor in making these repairs often damage the tube sheets in tube removals and egg the tube hole by improper rolling. At an isolated plant it would be advantageous to instruct the plant personnel responsible for the boiler maintenance in correct procedures for tube rolling and tube replacements.

12. Furnace Repairs

The furnace refractory should be maintained in good condition by periodic coating of the walls to prevent the fire or hot combustion gases from deteriorating the mortar around the brick. The time between coatings will depend on the firing condition of the boiler; usually a spray or brush coating at two year intervals will be satisfactory. Light spalling or cracking out of the brick can be repaired by a spray coating applied in successive ⅛ inch layers to return the wall to original thickness. Where the brick was cracked out to ½ its original thickness, it will require replacement of the affected section. The tile or castable baffles must be maintained in good condition to direct the combustion gases in their proper channel through the boiler.

13. Instruments and Controls

The instrument repairmen should be alerted prior to yearly shutdowns. A pre-check of instruments and controls while the boiler is in operation will

aid greatly in determining the degree of inspection and repairs required while the unit is out of service.

14. Burners

The cleaning and maintenance of the burners varies as to the different types of burners in use. In all cases the gas or oil orifices should be examined for plugging or wear. The spud, ring or arm type burners should be cleaned as found necessary.

15. Other Appurtenances

(Draft fans, turbines and air preheaters.) The draft fans usually require very little attention other than maintaining the proper oil level in the shaft bearings. The blades of course should be kept clean and periodically checked for unbalance. The turbines or motors for fan drive should be checked by experienced personnel once each year and repairs or adjustments made as found necessary. The regenerative type air preheaters are cleaned while the boiler is in operation. Checking oil level in the bearings should be a daily practice. The replacement of radial and/or circumferential seals will usually be governed by the sulphur content of the fuel; this replacement period can vary from one to several years. Tubular air preheater maintenance will also be governed primarily by the sulphur content of the fuel.

Other boiler auxiliaries such as soot blowers, economizers etc., will of course fall into the general inspection and maintenance schedule as outlined for the various other boiler accessories.

PREVENTION

The key to low maintenance and good service is a preventive method, embodying the early detection of wear or deterioration and the correction of trouble before it assumes serious proportions. It is through the use of systematic records that the ideal level of maintenance can be achieved.

The most important phase of boiler inspection is of course the prevention of failure from a boiler explosion with the possible resulting loss of life and property damage. The degree of inspection (a visual external inspection or partial to complete dismantling) should depend on the critical functions of the various parts to the safe operation of the boiler. Some of these inspections and maintenance procedures will, therefore, be performed at least once each year as routine maintenance procedures to such items as safety valves, steam gages, water columns and gage glasses. A visual external inspection will suffice for other non-critical parts such as drum internals where if no plugging or deposits are noted on the steam dry-pipe or separators, feed water spreader or continuous blow-down line, it is obviously unnecessary to remove or dismantle any of these parts for an internal inspection; a hammer test will readily indicate any internal scale build up. Auxiliaries which have moving parts such as the steam non-return valve and the mechanical units such as the steam turbine for feed water pumps or fan drive etc. will be inspected and maintenance provided as determined by past operating experience and records. These records will provide a key to minimum maintenance for trouble free operation.

REPORTS

A basis for systematic record files can be accumulated from inspection reports, maintenance reports and daily operating logs. The internal boiler inspection reports can best be made in letter form; a number of different types of boilers might require too lengthy a form to include all items which might apply only in part to the boiler under consideration. The external boiler inspection reports can be standardized on any form which gives the desired information regarding the boiler and its auxiliaries while in operation. The maintenance reports can also be standardized for an acceptable report form to include most items commonly checked at each boiler shutdown.

TOOLS

Today's inspection tools have advanced beyond the old original but still necessary tool—the boiler inspector's hammer. For non-destructive testing, some form of ultrasonic testing equipment is used for thickness measurements in detecting corrosion and/or erosion in tubes or shell plates; because of its portability, the most common instrument is one employing the resonance method. (Figure 3.)

A number of different methods are used to detect cracks in welds or at riveted joints. Some of these are magnetic-particle inspection (Figure 4), flourescent-magnetic-particle inspection, dye-penetrant method and fluorescent-penetrant method. Of these various methods for detecting surface flaws and cracks, the magnetic-particle inspection is the one most commonly employed for field use.

The determination of scale thickness in the tubes of water tube boilers by visual inspection is very difficult except at tube ends. A boiler tube scale thickness indicator (Figure 5) has been developed to accurately measure the scale and indicate its thickness in thousands of an inch through the length of the tube. This instrument will be found very useful in checking effectiveness of mechanical cleaning and to evaluate the benefits of changes in feed water treatment.

New instruments are constantly being developed to aid inspection through non-destructive testing. It is through the selective use of these tools that our preventive maintenance program can be most effective and that we may realize our goal of optimum operating efficiency consistent with safety and lowest maintenance costs. ##

About the Author

Elmer Mason is supervising boiler and vessel inspector for the Natural Gasoline Department of Phillips Petroleum Company. Though residing in Phillips, Texas, he reports to the Bartlesville office. After studying metallurgy at the University of Oklahoma, he started with Phillips as a welder. From jobs as a field mechanic and boilermaker, he was promoted to his present position in 1948.

Gulf HDS Turns Resid Into Cat Feed

Now Gulf changes emphasis for HDS process. Results: Atmospheric and vacuum residues can be converted into catalytic cracking feeds which are equal or superior to virgin gas oils

Harold Beuther and Richard A. Flinn
Gulf Research and Development Company
Pittsburgh, Pa.

BY MEANS of hydrogenation at 2,000-3,000 psig., it is possible to convert atmospheric and vacuum residues to high-quality catalytic cracking charge stocks. Nitrogen and metals contents, which are of particular importance in the subsequent catalytic cracking, are reduced to acceptable levels by hydrogenation. High catalyst activity is obtained in the hydrogenation (HDS) process by careful control of pore structure and the proportion of active components present, and long catalyst life is assured by a technique which has been developed for removing contaminating metals selectively.

Catalytic cracking of the hydrogenated residues has shown them to be equal or superior to virgin gas oils in most respects. It is possible by applying the system of HDS-processing and catalytic cracking to completely eliminate residual fuel production from the refinery. Economically, this process becomes competitive with more conventional residue handling methods as the price of No. 6 fuel oil declines relative to crude and distillate products.

INTRODUCTION

Much of our early work on the hydrogenation of residues was directed either toward desulfurization or toward obtaining a high degree of conversion during hydrogenation.[1] It was found that, while a reasonable level of desulfurization was possible at rather low conversions, the economic incentive for producing a low sulfur residue was small and did not support the processing costs required. The economics of residue hydrogenation were found to be somewhat improved if a hydro-cracking function were added to the desulfurization reaction to obtain more lower boiling distillates. However, the improvement in economics due to the greater distillate yield was not sufficient to make the process an economically attractive one. It became apparent that a very high degree of conversion of the residue to distillate products would be required. At the same time, the fact that increased conversion during hydrogenation meant parallel increases in processing costs led to the belief that at least partial nonhydrogenative conversion would be desirable. Thus, the concept was formed of a residue hydrogenation process designed to produce largely a high quality heavy oil which would then be subjected to a more conventional conversion scheme, such as catalytic cracking.

LOW-PRESSURE HDS PROCESSING

Although conversion to distillate products can be used as a measure of reaction severity in residue hydrogenation, experience has shown such a measure does not reflect the many basic differences in the character of the reaction. "Moderate severity" hydrogenation of 18% Kuwait residue can be carried out continuously at 500-1,000 psig. to convert about 25% of the residue to furnace oil and gasoline, 30% to a heavy gas oil, and the remainder to a partially desulfurized residue.

The heavy gas oil portion of a hydrogenated product,

TABLE 1—Inspections of Low-Pressure HDS Gas Oil from Kuwait Residue

	1000 PSIG HDS Gas Oil	Virgin Kuwait Gas Oil
Gravity, °API	21.0	22.2
Aniline Point, °F	162.0	170.5
Total Nitrogen, Percent	0.245	0.131
Basic Nitrogen, Percent	0.117	0.041
Carbon Residue, Percent	1.0	0.7
Sulfur, Percent	0.6	3.1
Vanadium, ppm	0.1	0.2
Characterization Factor	11.64	11.76

TABLE 2—Catalytic Cracking of Kuwait HDS Gas Oil Produced at 1000 Psig

	1000 PSIG Kuwait HDS Gas Oil	Virgin Kuwait Gas Oil
Cracking at Constant Reactor Conditions (1.5 Space Velocity, 930° F.)		
Gas Oil Conversion Volume Percent	44.1	60.0
Depropanized Gasoline Volume Percent	32.4	53.5
Carbon, Weight Percent	8.4	6.3
Cracking at Constant Conversion (50 Percent)		
Space Velocity, Wt./Hr./Wt.	1.0	3.2
Depropanized Gasoline, Volume Percent	35.6	46.0
Carbon, Weight Percent	10.5	3.9

however, is rather unusual in its cracking characteristics. Analyses of this gas oil would suggest it might approach virgin gas oil in quality as a cracking stock. A comparison of these two materials is shown in Table 1.

The slightly lower characterization factor and aniline point of the gas oil from residue HDS would not be expected to cause major differences in cracking response. However, upon subjecting the stock to cracking in a small-scale fluid catalytic cracking apparatus[2] it was found that the HDS gas oil responded rather poorly. Not only was this stock more difficult to convert, but the carbon production was disproportionately high and the gasoline production low (Table 2).

The poor cracking response of the hydrogenated oil can be attributed possibly to its nitrogen content. Although the total amount of nitrogen present is not quite double that present in virgin Kuwait gas oil, the amount of basic nitrogen is nearly three times as great. The effect of basic nitrogen compounds on acidic cracking catalysts has been known for some time, and recent data have illustrated the adverse cracking results obtained in the presence of such materials.[3]

Since the heavy gas oil fraction of the product obtained from moderate pressure residue HDS is not of good quality, it is better to consider the product as a high-quality residual fuel oil plus gasoline and furnace oil. In such an application, Kuwait vacuum residue yields 5% gasoline, 20% furnace oil, and 76% low-sulfur No. 6 fuel oil (Table 3).

The moderate-pressure processing technique is doubly attractive because of the substantial reduction in No. 6 fuel oil yield along with the rather low sulfur content of this residual fuel. With the very high sulfur content Kuwait residue, the 80% desulfurization obtained still leaves about 1% sulfur in the product. With a charge stock of lower sulfur level, the residual product fraction is extremely low in sulfur.

A direct comparison of the residual fuel oil produced in a Kuwait Crude Refinery with and without HDS processing at 1,000 psig. is shown in Table 4. It is possible to reduce the yield of No. 6 to less than half its virgin value. HDS operations at the conditions described here have been carried out continuously in pilot plant operation for periods up to one month, and on-stream periods of at least this length are anticipated for commercial operations. The hydrogen consumption for such conversion is about 450 scf per barrel of charge.

TABLE 3—HDS Processing of Kuwait Vacuum Residue (Operating Pressure: 1000 PSIG)

Charge Stock	
Gravity, °API	5.5
Sulfur, Percent	5.5
Viscosity, SUV at 200 F	22,130.
Carbon Residue	23.1
Vanadium, ppm	102
Gasoline (IPB—400F.)	
Yield, Volume Percent	5
Sulfur, Percent	0.17
Aromatics, Percent	15.0
Naphthenes, Percent	21.1
Furnace Oil (400—650 F.)	
Yield, Volume Percent	20
Gravity, °API	33.7
Sulfur, Percent	0.2
Diesel Index	43.6
Residue (650 F. +)	
Yield, Volume Percent	76
Gravity, °API	13.0
Sulfur, Percent	1.0
Viscosity, SFS at 122° F.	200
Carbon Residue, Percent	14.6
Vanadium, ppm	13.2

HIGH PRESSURE HDS PROCESSING

In order to overcome the shortcomings of the heavy gas oil cracking stock produced at 1,000 psig., higher pressure operation is required. The use of high pressure brings about a number of changes in the character of the HDS reaction, one of the most significant being the effect on the nitrogen content of the heavy gas oil. Comparison of the heavy gas oil made from Kuwait residue at 1000 psig. with that made at 3,000 psig. is shown in Table 5.

Increasing the pressure from 1,000 to 3,000 psig. reduced the basic nitrogen content by almost 50%. The 0.062% basic nitrogen remaining in the 3,000 psig. HDS gas oil approached the 0.041% present in virgin Kuwait gas oil. At the same time the characterization factor and aniline point increased in the high-pressure

TABLE 4—The Effect of 1000 PSIG HDS On No. 6 Fuel Oil Production
(Basis: Kuwait Crude Refinery)

	Blending of Virgin Vacuum Residue	Use of 1000 PSIG HDS Processing
Yields, Volume Percent of Crude		
Vacuum Residue (1030° F. +)	18.0	....
HDS Residue (650° F. +)	....	13.5
Cutter Oil Requirement	10.7	0.0
Total No. 6 Fuel Oil (200 SFS at 122° F.)	28.7	13.5
Inspection of No. 6 Fuel Oil		
Gravity, °API	12.5	13.0
Sulfur, Percent	4.7	1.0
Carbon Residue, Percent	15.2	14.6
Vanadium, ppm	67	13

gas oil, but it would not be expected that the relatively minor changes in these properties would markedly affect the cracking results.

A striking difference in cracking properties is achieved, considering a variation in nitrogen content appears to be the only significant difference between the gas oils made at 1,000 psig. and those made at 3,000 psig. The information in Table 6 shows the 3,000 psig. gas oil is much more readily converted to a high yield of gasoline than is the gas oil made at 1,000 psig. It appears the nitrogen content may be a controlling factor in determining the quality of gas oils produced by residue hydrogenation.

As the pressure of hydrogenation is increased, another reaction begins to occur which has an important effect on the product properties. While desulfurization is the dominant reaction at low pressures (1,000 psig. and less), higher pressure operation brings on a significant amount of saturation of aromatic compounds. This is of particular importance in residue hydrogenation since the asphaltic components are known to be rich in aromatic nuclei. The result of a saturation of these components is to produce a very high molecular weight asphaltic oil of exceptional cracking properties.

By operating in the pressure range from 2,000 to 3,000 psig., it is possible to attack the asphaltic constituents so as to reduce metals content, carbon residue, and nitrogen to such levels that the entire furnace oil-free product (that boiling above 670° F) from HDS processing can be charged directly to a catalytic cracking unit, thus eliminating vacuum distillation from the refinery. The use of this oil as cracking stock produces gasoline of higher quality and yield than can be obtained from virgin gas oil. To obtain very low levels of contaminants and the highest possible characterization factor, it is desirable to charge an atmospheric residue rather than a vacuum residue, although the latter can be hydrogenated and cracked successfully.

The method of distillation used commercially by Gulf on Kuwait Crude gives an atmospheric residue containing two-thirds of the virgin catalytic cracking charge stock. The other one-third is removed as a distillate fraction from the atmospheric tower.

When HDS processing the atmospheric tower bottoms from such a distillation, it is possible to increase the space velocity over that required by the vacuum residue to compensate for the extra oil present and still derive the benefits mentioned above in effecting better hydrogenation. The added gas oil reduces the viscosity of the residue in the catalyst pores to allow more effective contacting of the asphaltic molecules to be treated. In addition, the additional light oil serves as a hydrogen reservoir for the larger residue molecules.

Typical results from the hydrogenation of Kuwait and Mid-Continent atmospheric residues are shown in Table 7. The hydrogenation of residues using the proper balance of operating conditions can proceed in extremely long cycles. The amount of hydrocracking is only slight, as the yields of light distillates indicate, and is mainly due to sulfur elimination. The product consists very largely of a refined heavy oil which has properties suggesting its use at a catalytic cracking charge.

Notable in the analytical properties of such stocks are the unusually high characterization factors and the relatively low nitrogen contents. Nitrogen, which proved to be so important in the products from vacuum residue hydrogenation, is present in lesser amounts in the 3,000 psig. hydrogenated residues than in the virgin gas oils from the same crude.

The coke-conversion curve is plotted in Figure 1 from cracking experiments charging the 670° F. + products from 3,000 psig. HDS-processed Kuwait atmospheric tower bottoms. Similar data are shown on Figure 2 for a 3,000 psig. hydrogenated Mid-Continent residue in comparison with the virgin gas oil. Even though the HDS-processed stocks have carbon residues which are 5 to 10 times those of the virgin gas oils, they did not produce a proportionate amount of carbon. In fact, the hydrogenated Kuwait stock yielded approximately the same amount of carbon as the virgin gas oil did. The hydrogenated Mid-Continent residue produced about twice the amount of carbon as the comparable virgin gas oil.

Both hydrogenated residues cracked much more readily than virgin gas oil. For example, conditions which gave 60% conversion of the virgin Kuwait oil gave 67% conversion of the hydrogenated residue (Figure 3). The response of the hydrogenated Mid-Continent residue to cracking was even greater, since conditions giving 60% conversion of the virgin Mid-Continent gas oil gave 74% conversion of the hydrogenated residue (Figure 4).

It is significant that the rather high carbon residues

TABLE 5—The Effect of Pressure on the Quality of HDS-Produced Kuwait Gas Oils

	KUWAIT GAS OIL	
	1000 PSIG HDS	3000 PSIG HDS
Gravity, °API	21.0	21.7
Aniline Point, °F	162.0	172.0
Total Nitrogen, Percent	0.245	0.157
Basic Nitrogen, Percent	0.117	0.062
Carbon Residue, Percent	1.0	1.2
Sulfur, Percent	0.6	0.2
Vanadium, ppm	0.1	<0.1
Characterization Factor	11.64	11.74

TABLE 6—The Effect of Pressure on the Cracking Characteristics Of Kuwait HDS Gas Oils

	1000 PSIG HDS Gas Oil	3000 PSIG HDS Gas Oil	Virgin Kuwait Gas Oil
Cracking at Constant Reactor Conditions (1.5 Space Velocity)			
Gas Oil Conversion Volume Percent	44.1	56.0	60.0
Depropanized Gasoline, Volume Percent	32.4	45.0	53.5
Carbon, Weight Percent	8.4	8.1	6.3
10 RVP Gasoline Octane Rating, Research +3.0 cc. TEL	96.0	98.0	96.1
Cracking at Constant Conversion (50 Percent)			
Space Velocity, Wt./Hr./Wt.	1.0	2.7	3.2
Depropanized Gasoline, Volume Percent	35.6	40.9	46.0
Carbon, Weight Percent	10.5	6.4	3.9
10 RVP Gasoline Octane Rating, Research +3.0 cc. TEL	96.5	97.3	94.9

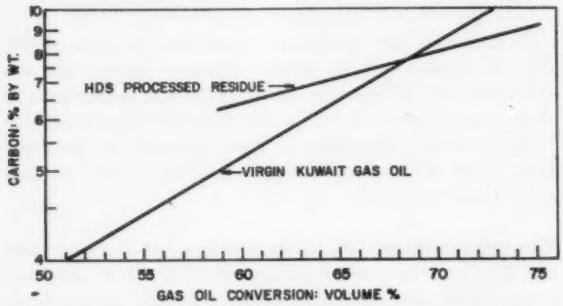

FIGURE 1—HDS-processed stocks produced about the same amount of carbon as did virgin stocks. (Cracking conditions: 930° F, 10:1 catalyst-to-oil.)

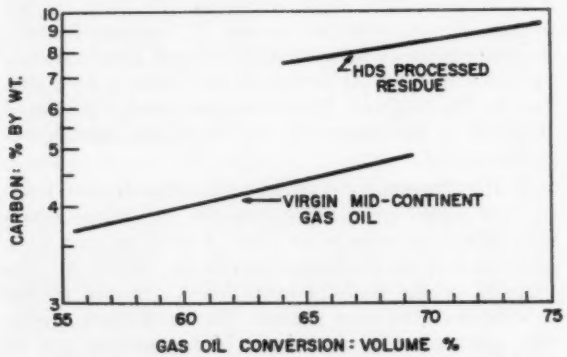

FIGURE 2—Hydrogenated Mid-Continent residue produced only about twice as much carbon as did the virgin charge. (Cracking conditions: 930° F, 10:1 catalyst-to-oil.)

of the HDS products were not completely reflected as carbon yields in catalytic cracking. This indicates that the very large molecules found in the hydrogenated residue form a measured carbon residue which does not represent their true behavior in catalytic cracking. It seems likely that these materials yield carbon residue in a thermal pyrolysis such as the carbon residue test involves because of their molecular weight and that such a carbon residue does not accurately reflect the coking tendency in a catalytic cracking process.

It has been observed before[4] that the oil portion of a residue is quite susceptible to catalytic cracking with relatively low carbon yield if the asphaltene and resin fractions are first removed by solvent precipitation. Hydrogenation serves to convert the asphaltene and resin fractions to "oil" which can be readily cracked. This is quite significant, since about 14% of Kuwait crude is resin or asphaltene which would otherwise be useful only as a residual fuel.

The product distribution and quality obtained from a typical example of catalytic cracking an HDS-processed residue is shown on Table 8. The virgin gas oil and hydrogenated residue crack similarly in all respects except that the gasoline produced from the residue has an octane advantage of several numbers. Of course, the sulfur contents of all the cracked products are much lower from the residue charge. It is also quite significant that the 11.43 characterization factor of the heavy catalytic gas oil from the hydrogenated residue is much higher than that of the same fraction from virgin gas oil. This gas oil should make a much better recycle cracking stock than the usual heavy catalytic gas oil.

As was mentioned before, it is also possible to obtain a product suitable for catalytic cracking by hydrotreating the vacuum residue at 3,000 psig. In this case the furnace-oil-free product is not quite as good as that from the atmospheric residue, but the more critical features—nitrogen and metals—can be brought to the desired low levels. The cracking results obtained from such a product do not compare as favorably with those from virgin Kuwait gas oil as do the results from the hydrogenated atmospheric residue. However, they are not at all unreasonable. At 50% conversion, about 32% gasoline and 20% light gas oil were obtained along with 10% carbon. As with the hydrogenated atmospheric residue, the gasoline octane ratings are unusually high and all sulfur contents are quite low.

One property of these hydrogenated residual stocks which is not superior is their nickel content. In our hydrogenation studies we have found nickel to be more difficult to remove than vanadium. Early in a process period vanadium is removed in excess of 99.9% and, as the catalyst ages, this removal may decrease to 98%-99%. With nickel, however, removal is never complete and, starting at about the 98% level, removal declines to about 93% after one month. Nickel analytical values, however, are not as reliable as might be desired for several reasons. One which appears to contribute substantially to the poor reliability of such determinations is the contamination of products with minor amounts of nickel from the nickel-alloy equipment. At the level of 0.1 ppm nickel, such a factor as this assumes major importance. Nevertheless, at present the nickel contents of the hydrogenated products from residues represent a problem which is receiving attention.

A very marked effect upon the yield distribution is obtained when the HDS process is applied to residues from a refinery (Table 9). The yield of residual fuel oil from Kuwait crude goes to zero while the quantity of cracking stock is increased by 60%. In addition to the catalytic cracking charge stock produced by hydrogenation of the residue, which amounts to 88% from Kuwait residue and 96% from Mid-Continent residue,

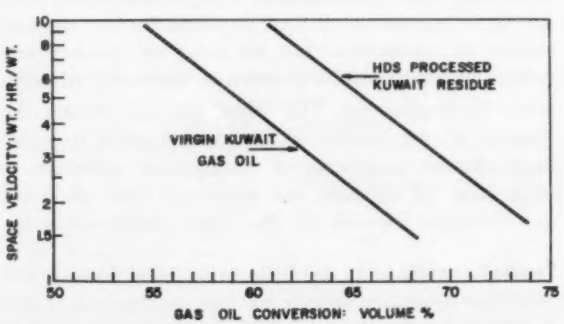

FIGURE 3—Hydrogenated residue cracked much more readily than virgin gas oil. (Cracking conditions: 930° F, 10:1 catalyst-to-oil.)

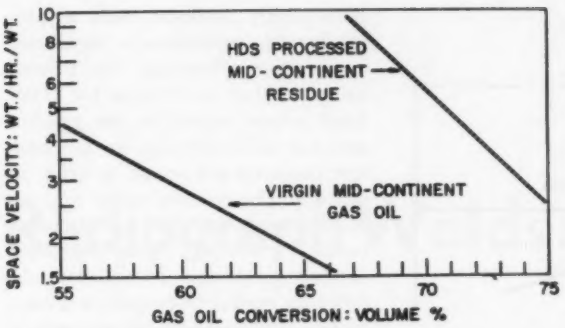

FIGURE 4—Conditions giving 60 percent conversion of the virgin Mid-Continent gas oil gave 74 percent conversion when the charge was hydrogenated beforehand. (Cracking conditions: 930° F, 10:1 catalyst-to-oil.)

moderate yields of a high-quality furnace oil are produced along with a small yield of gasoline.

In processing of this type, the yields of gasoline and furnace oil are reduced as pressure is increased. Also, at a given pressure the yields of these lighter products depend upon the sulfur content of the charge stock, with high sulfur stocks yielding more of the light distillates. Hydrogen consumptions for the type of operations converting atmospheric residues to cracking stock (Table 7) vary from 800 to 1,200 scf per barrel of charge, depending upon the conditions used and the nature of the charge stock.

As in most residue hydrogenation processes there is a reduction in catalyst activity with time. Initially, an activity edge is lost from the catalyst over a period of several days. After this loss the activity remains essentially constant in the 2,000-3,000 psig. operations and declines only gradually in the 1,000 psig. process. It has been found that generally the catalyst remains active as long as the coke-on-catalyst level is below about 30%. After one month operation at 3,000 psig. with Kuwait atmospheric residue, the coke level was only 10% while a similar operation at 1,000 psig. charging Kuwait vacuum residue left about 30% coke. Thus, regeneration of the low-pressure process would occur on a monthly basis while the high-pressure operation should operate in cycles of about six months.

TABLE 7—High-Pressure Hydrogenation of Atmospheric Residues To Produce Cracking Stocks

	Kuwait Atmospheric Residue		Mid-Continent Atmospheric Residue
	2000 PSIG	3000 PSIG	3000 PSIG
Yields, Volume Percent			
Gasoline	3	2	3
Furnace Oil	15	12	3
Residue (670° F.+)	84	88	96
Inspection			
Gasoline			
Sulfur, Percent	0.04	0.04	0.04
Aromatics, Percent	9.5	16.2	8.5
Naphthenes, Percent	28.5	32.1	39.3
Furnace Oil			
Gravity, °API	32.5	34.6	40.1
Sulfur, Percent	0.04	0.05	0.04
Diesel Index	40.9	40.0	51.0
Residue			
Gravity, °API	21.5	23.1	23.2
Sulfur, Percent	0.51	0.27	0.04
Nitrogen, Percent	0.160	0.114	0.133
Carbon Residue, Percent	3.3	2.9	3.4
Vanadium, ppm	0.5	<0.1	0.5
Nickel, ppm	1.1	0.3	0.8
Characterization Factor	11.95	12.07	12.11

Metals deposition from the charge stock is a factor which must be considered in establishing catalyst life. At pressures of 2,000-3,000 psig., essentially all metals in the oil are deposited on the catalyst. In time these deposits can become so large they interfere with the functioning of the catalyst. The catalyst must then be regenerated and washed with a complexing agent to remove the unwanted metals. We have found dilute aqueous solutions of certain agents selectively form soluble coordination compounds with the undesirable metals and allow them to be washed from the catalyst. Activity studies on catalysts treated in this manner show them to be restored to normal activity. On this basis, a catalyst life of at least two years is anticipated.

ECONOMICS OF HDS PROCESSING TO PRODUCE CATALYTIC CRACKING CHARGE STOCKS

The economics of residue conversion processes depend to a large extent upon the differential between residual fuel oil price and crude and distillate prices. The fact that residual fuel oil is the lowest value product made and that its price fluctuates considerably makes it desirable to eliminate this product if possible. As with most processes the economics of HDS are quite involved and depend to a large extent not only upon a particular refiner's situation but also upon the condition of the residual fuel oil market. It is not the purpose of this

TABLE 8—Typical Product Distribution and Quality from Catalytic Cracking
(Cracking Condition: 61% Conversion, 930° F., 10:1 Catalyst-to-Oil)

	HDS-Processed Kuwait Atmos. Residue	Virgin Kuwait Gas Oil
Yield, Volume Percent		
C_2 and Lighter (Percent by Weight)	3.2	3.6
Propane	2.2	3.1
Propylene	5.6	5.5
Butane	3.9	4.4
Butene	7.6	7.2
Pentane	2.5	2.6
Pentene	4.7	6.4
Debutanized Gasoline	45.2	43.6
Light Catalytic Gas Oil	14.8	17.4
Heavy Catalytic Gas Oil	23.6	21.6
Carbon (Percent by Weight)	6.4	5.4
Product Quality		
10 RVP Gasoline		
Octane Ratings		
Research, +3.0 cc. TEL	97.8	95.8
Motor, +3.0 cc. TEL	83.4	80.6
Sulfur, Percent	0.03	0.33
Light Catalytic Gas Oil		
Gravity, °API	22.4	19.5
Sulfur, Percent	0.24	3.29
Aromatics, Percent	75.0	69.1
Heavy Catalytic Gas Oil		
Gravity, °API	19.1	11.5
Sulfur, Percent	0.54	3.90
Carbon Residue, Percent	2.08	2.95
Characterization Factor	11.43	10.58

TABLE 9—Increased Yields of Cracking Stock from Kuwait Crude By HDS Processing

Yields: Percent of Crude	Vacuum Distillation and Blending of No. 6 Fuel Oil	HDS Processing Atmos. Residue at 3000 PSIG
Catalytic Cracking Charge Stock from:		
Atmospheric Tower	11.0	11.0
Vacuum Tower	20.0	....
HDS Processing	....	39.0
Total	31.0	50.0
Residual No. 6 Fuel Oil from:		
Vacuum Bottoms	18.0	0.0
Cutter Stock	10.7	0.0
Total	28.7	0.0

Gulf HDS Turns Resid Into Cat Feed . . .

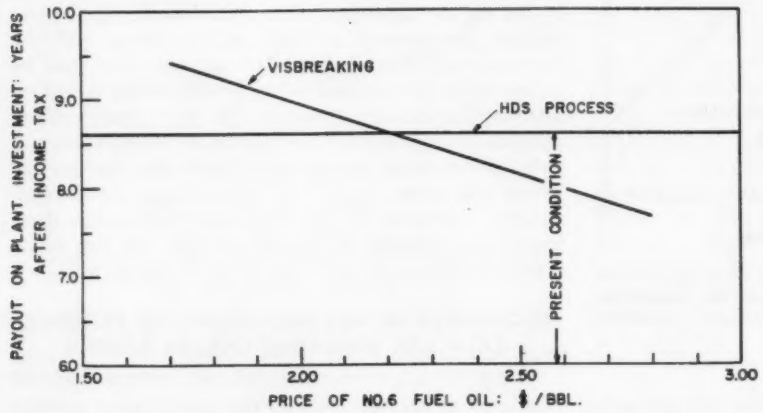

FIGURE 5—If the price of No. 6 fuel oil goes below $2.20 per barrel, hydrogenation is better than visbreaking for this typical case of a 100,000 bpcd refinery processing Kuwait crude.

paper to delve into economics deeply, but a brief examination of the effect of market fluctuations on HDS economics is of interest.

A number of conversion schemes are currently used to minimize residual fuel oil production, one of the most attractive of which is thermal visbreaking. However, even after visbreaking of the residue a substantial quantity of residual fuel oil remains. Thus, the economics of visbreaking are subject to variations in the market price of this product. Since HDS followed by catalytic cracking does not produce a residual fuel, it is not affected by fluctuations in the market price.

Figure 5 illustrates the comparative economics of the Gulf HDS Process and visbreaking in refinery schemes for processing 100,000 bpcd of Kuwait crude. Under conditions about typical of present prices and manufacturing costs, where a refinery scheme including visbreaking of residuum would show a payout of eight years (after income taxes), one including the HDS process would have a payout of about 8.6 years. However, as the price of No. 6 fuel oil decreases, the economics tend to favor the Gulf HDS Process. This effect is shown in Figure 5 where the price of No. 6 fuel oil is varied, all other factors being held constant. At a price of about $2.20 per barrel under the conditions assumed the two processes are about equivalent. At lower prices for No. 6 fuel oil HDS processing is actually preferable to visbreaking.

Coking is another residue conversion process with economics which are independent of the No. 6 fuel oil price. However, the limited market for coke, the difficulties encountered in handling, and the poorer quality of the liquid products from coking are factors that favor the selection of the alternate processes of visbreaking and hydrodesulfurization.

The product quality obtained by HDS has been shown to be substantially better than that obtained in conventional processing. With the continuing trend towards high-quality products, such a quality benefit represents a significant competitive advantage for refiners using residue conversion by HDS. High octane rating for the gasoline and low sulfur content for all distillate products are bound to offer incentives. The reduced sulfur contents of the products offer an attractive outlet for refiners facing legislated product properties. In addition, the fact that residue hydrogenation completely eliminates the dependence of profitability on the price of No. 6 fuel oil is an advantage, since the salability of the low-value No. 6 can become a major factor in determining the refiner's mode of operation.

Original presentation was before the American Institute of Chemical Engineers, San Francisco, December 6-9, 1959.

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About the Authors

Beuther

Harold Beuther is head of the Process Research Section of Gulf Research and Development Co., Pittsburgh, Pa., where he supervises research in fuels and lubricants. Holder of a B.S. degree from Carnegie Institute of Technology, he has authored or coauthored about 25 patents and publications in the field of petroleum refining. He has previously worked in one of Gulf's refineries and has performed pilot plant development work.

Flinn

Richard A. Flinn is a group leader for Gulf Research and Development Co., where he supervises work in hydrogenation process, studies of heavy oil and middle distillates, and catalyst development. Holder of a B.S. degree in chemical engineering from Grove City College and a Ph.D. degree in physical chemistry from University of Pittsburgh, Dr. Flinn has published in the fields of hydrocracking, hydrodesulfurization, catalysis, and metal and salt solid solutions.

Radiograph Welds and Cut Vessel Costs

Higher welded joint efficiencies are allowed by the ASME Unfired Pressure Vessel Code, thus thinner heads and shells, if the vessel is radiographed

Robert Chuse
Leonia, N. J.

THE USE of radiography is increasing rapidly in the welded pressure vessel industry. This is especially so since the ASME Unfired Pressure Vessel Code allows higher welded joint efficiencies in a vessel that is radiographed and spot radiographed. Therefore, a vessel can be built for the same pressure and diameter using thinner shells and heads, consequently less weld metal and welding time, if it is radiographed.

X-ray radiographs show defects more sharply. Gamma rays show less contrasting pictures. This must be taken into account when interpretation of the film is made. Persons who are experienced with gamma rays, when shifted to X-ray work, tend to see any defect as a cause for rejection, while those experienced with X-ray film, may tend to underestimate the seriousness of a defect seen on a gamma ray film.

The ASME Code states that "The weld shall be radiographed with a technique which will indicate the size of defects having a thickness equal to, or greater than, 2 percent of the thickness of the base metal."

Thickness Gages. As a check on the radiographic technique, penetrameters or thickness gages are used. The thickness of the penetrameter must not be more than 2 percent of the thickness of the plate being radiographed, but for thin plates, it need not be less than 0.005 inches.

Sensitivity, as measured by the penetrameter, is understood to be the smallest fractional thickness difference in the material being radiographed, which can be detected visually on a radiograph.

When a welded seam has the weld reinforcement left on, and/or a backing strip is not removed, a shim of the same material as the backing strip must be placed under the penetrameter so that the total thickness being radiographed under the penetrameter is the same as the weld, weld reinforcement, and backing strip if not removed.

Each penetrameter must have three holes of diameter equal to two, three, and four times the penetrameter thickness, but not less than 1/16 inch. Except when gamma rays are used as a source of radiation, the smallest hole need not be less than 3/32 inch.

The smallest hole must be distinguishable on the film.

The penetrameters should be placed on the side nearest the source of radiation. (They may be placed on the film side of the joint provided that the radiographic technique is proven to be adequate.)

At least one penetrameter must be used for each film and placed at the end of the exposed length, parallel and adjacent to the welded seam, with the smallest hole at the outer end. When the source of radiation is placed on the axis of the joint and the complete circumference is radiographed with a single exposure, four uniformly spaced penetrameters are to be used.

Defects. Proper radiography will show any change in metal thickness above the two percent contrast sensitivity required by the ASME Code. Any defect larger than the minimum size, such as slag entrapment, porosity, lack of penetration, undercutting and cracks, will show on the radiograph since these defects represent less metal thickness, and therefore more radiation passes through the area of the defect. They will be recorded on the film as dark areas when compared with the normal density of the sound metal areas. Weld reinforcements, backing strips, splatter and icicles will show on the film as light areas, because they represent metal sections thicker than the average plate

thickness. In burn through areas, the burn through in itself is a darker irregular image but the drip through surrounding the blow through is a lighter image. In high absorption material such as the burn off from an electrode used in heliarc welding, the burn off shows up as light density areas usually spherical in shape. Not every discontinuity in film density is objectionable for vessels that are to be entirely radiograhed. The code permits certain slag inclusions according to the plate thickness, such as:

- ¼ inch for plate thickness up to ¾ inch,
- ⅓ thickness of plate for thickness of plate from ¾ inch up to 2¼ inch,
- ¾ inch for thickness of plate over 2¼ inch.

Any group of slag inclusions in a line that have a total length greater than the thickness of plate in a length of twelve times the plate thickness, except when the distance between the successive imperfections exceed six times the length of the largest imperfection, is not acceptable.

Any type of crack or lack of penetration is not acceptable and shall be repaired.

Porosity is judged by comparison with the standards shown in the code.

When only spot radiography is required, the standards are less demanding. The length of the film need be only 6 inches, but not less.

Porosity is not a factor in the acceptability of welds that are to be spot radiographed.

Also note the difference in other defects allowed. Any weld that shows cavities or elongated slag inclusions shall be unacceptable if it has a greater length than two-thirds thickness, where thickness is the thickness of the thinner plate of the welded joint.

Any group of imperfections in a line, that have a total length greater than the plate thickness in a length of six times the plate thickness, and if the longest defect is not separated by acceptable weld metal equal to three times its length, it is not acceptable. (Since the minimum length required for a spot radiograph is six inches, this length shall be proportional for radiographs shorter than six times the thickness.)

Any defect shorter than ¼ inch is acceptable. Any defect longer than ¾ inch is not acceptable.

Welds which show any type of crack or lack of penetration are not acceptable and must be repaired.

When a spot radiograph shows welding which does not meet the code requirements, two additional spots must be taken in the same seam at locations chosen by the inspector away from the original spot, preferably one on each side of the defective section. If these additional spots do not meet the acceptable standard, the rejected welding shall be removed and the joint rewelded. Or at the fabricators option, he may completely radiograph the entire unit of weld represented, and the defective welding only need be repaired. The rewelded areas shall be spot radiographed.

All rewelded areas shall meet the code requirements.

Film Interpretation. For the proper interpretation of films, the view box should be well lighted with sufficient intensity to examine the darkest area of the film. This view box should be located in a room that can be darkened.

Film handling and processing at times will cause marks which can give the impression of weld defects. A fine scratch on the film surface may look like a crack. Water marks, stains and streaks may show up similar to a defect.

When the film surface is viewed in reflected light, these scratches and film surface defects can be seen.

Other conditions that may appear to be flaws in the weld, but are not, are surface markings such as a sharp weld overlay which will show contrast at the weld edge and scratches on intensifying screens.

When a backing strip is used, the weld penetration lines into the backing ring may be mistaken for a defect.

The above conditions may be apparent to a welding radiographic technician, or an experienced inspector, but are not so obvious to a person who does not generally interpret radiographic film.

In the preceding paragraph, conditions which may appear as flaws, but which in reality are not, have been defined. There are often defects in a weld that are difficult to determine. These are the ones to look for, keeping in mind that some critical materials are more prone to cracking and therefore require extreme consideration in the evaluation of film images.

A crack that runs perpendicular to the plate surface can easily be seen. But cracks along the fusion line often are on an angle and the defect image may not be sharp. Defects that are parallel to the plate may not show up.

As an example: If a laminated plate was radiographed with the radiographic beam perpendicular to the plate surface, the lamination, in all probability, could not be seen. However, if the plate was cut and radiographed with the radiographic beams parallel to the plate as rolled, these laminations would show clearly.

Cracks show up mainly longitudinally to the weld, in the weld, in the fusion line of the weld, at craters, and occasionally in the plate adjacent to the weld. Transverse cracks are not so often seen, but do appear in the weld and plate edges. Slag inclusions in a weld are usually sharp and irregular in shape. As stated before, certain small size slag inclusions are acceptable according to the Pressure Vessel Code, but elongated slag or many slag inclusions in a line are not desirable.

Incomplete penetration usually appears in a sharp delineation and is not acceptable. Undercuts usually are easily seen at the edge of a weld. Porosity in a weld shows up as small dark spots. These spots may be defined as fine porosity or coarse, and when complete radiographing is required, the acceptability is measured with standards shown in the code book.

The important thing in viewing radiographs, is to be sure that the penetrameters are properly placed and that the penetrameter holes show. If the radiographic technique is correct, the obvious defects will be seen, so look for the defects that are not so obvious.

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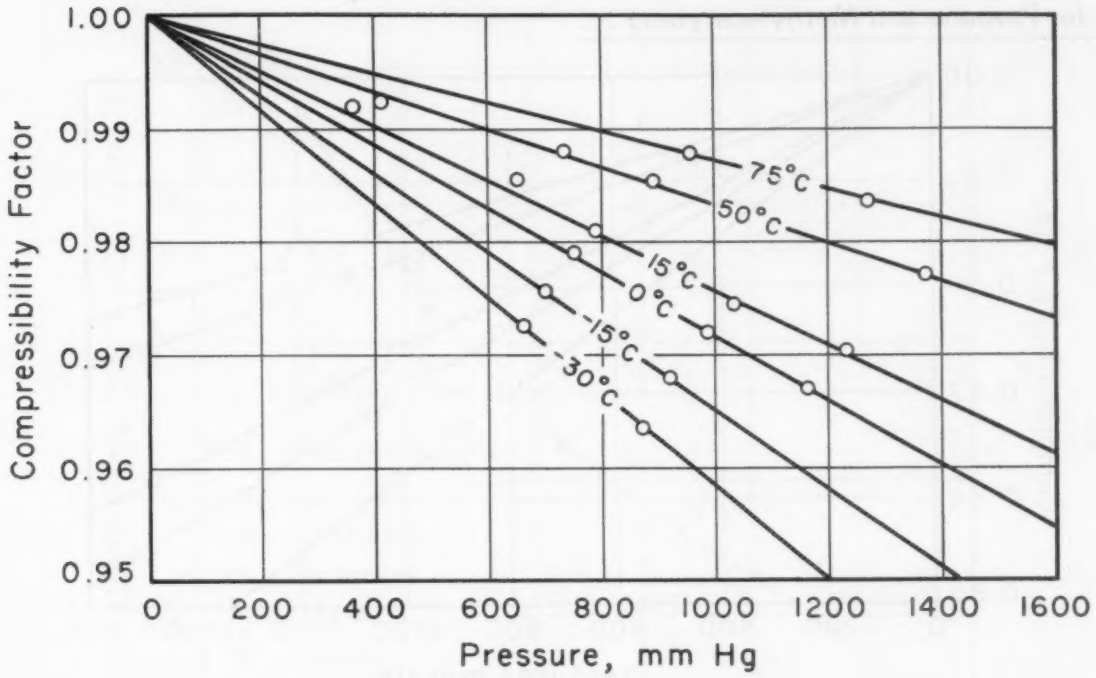

FIGURE 1—Compressibility factors for propane.

For low pressures . . .

Zs for Propane and Methylacetylene

Compressibilities of propane and of methylacetylene were determined below 2 atm. pressures and at temperature range of —30° to + 75° C.

Perry P. Dawson, Jr.* and John J. McKetta
The University of Texas, Austin

A GAS BUOYANCY balance was used to measure gas compressibilities of propane and methylacetylene below 2 atm., and over the temperature range of —30° C to + 75° C. Second virial coefficients were calculated from mean values of the compressibility factors. The error in the compressibility factor measurement was approximately ± 0.04%.

Method. The basic apparatus used in this investigation was originally developed by Edwards[3] for the determination of the densities of industrial gases. The apparatus was modified to increase accuracy and utility but the principle of operation remains the same.

In the gas density balance a metal bulb fastened to one end of a freely swinging balance beam is buoyed up by the gas surrounding it. This beam is contained within a gas-tight case with suitable outlets for evacuating and filling with gas. For a particular value of density of the gas within the case the beam will assume a horizontal position as indicated by a pointer at one end of the beam. The beam has movable counterweights attached to the end opposite the float bulb so that the "balancing" density may be varied.

In operation a reference gas whose properties are well known is used to determine the density value settings of the balance. From the general gas law

$$PV = ZnRT \qquad (1)$$

the expression for density may be derived:

$$d = \frac{PM}{ZRT} \qquad (2)$$

where P and T represent the balancing pressure and the temperature of the gas respectively. Since the balancing density remains constant for one particular counterweight setting then the densities at which two different gases balance the beam are equal, that is

$$d_r = d_x \qquad (3)$$

* Present address: El Paso Natural Gas Co., El Paso, Texas.

Zs for Propane and Methylacetylene . . .

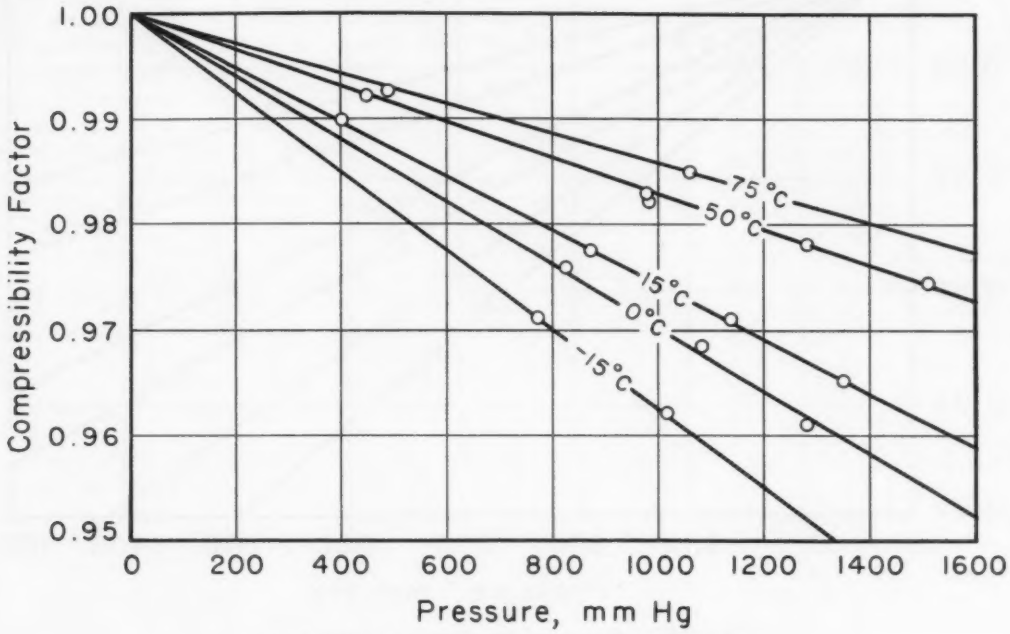

FIGURE 2—Compressibility factors for methylacetylene.

and

$$\frac{P_r M_r}{Z_r RT_r} = \frac{P_x M_x}{Z_x RT_x} \quad (4)$$

If the apparatus remains at constant temperature there results

$$Z_x = Z_r \frac{P_x M_x}{P_r M_r} \quad (5)$$

Knowing the compressibility of the reference gas and the molecular weights of both gases then the compressibility factor of the second may be found. Silberberg[10] describes other adaptations of this method where the molecular weight ratio, M_x/M_r can be determined as well.

Apparatus and Materials. The equipment used in this work was a modification of that used by Silberberg,[9, 10] Kuo,[6] and Pfennig.[8]

The propane sample used in this work was of research grade supplied by Phillips Petroleum Company. The sample used was analyzed for isobutane and air by gas phase chromatography. The results of this analysis were

Propane	99.96%
Air	0.04%
Isobutane	0.00%
	100.00%

The methylacetylene sample was purified and analyzed by Phillips. The results of that analysis by mass

TABLE 1
SECOND VIRIAL COEFFICIENTS

Temp. °C	$-B \times 10^3$ (atm^{-1})
A. Propane	
−30	31.43
−15	25.93
0	21.51
15	18.11
50	12.56
75	9.56
B. Methylacetylene	
−15	28.29
0	22.66
15	19.00
50	12.81
75	10.33

TABLE 2
EXPERIMENTAL RESULTS

Temperature °C	Press., mm	Compressibility Factor	Deviation From Linearity Percent
A. Propane:			
−30	665.23	0.97297	+0.048
−30	870.54	0.96363	−0.037
−15	927.65	0.96824	−0.008
−15	708.87	0.97592	+0.010
0	1164.43	0.96691	−0.013
0	752.31	0.97913	+0.042
0	986.89	0.97192	−0.015
15	1039.23	0.97494	−0.030
15	367.85	0.99233	+0.109
15	795.03	0.98107	+0.001
15	1232.65	0.97052	−0.011
15	655.78	0.98538	+0.101
50	737.28	0.98791	+0.009
50	1378.81	0.97712	−0.009
50	413.64	0.99271	−0.045
50	894.79	0.98548	+0.027
75	1270.72	0.98355	−0.047
75	967.73	0.98844	+0.061
B. Methylacetylene			
−15	1013.95	0.96210	−0.016
−15	776.42	0.97130	+0.020
0	1077.89	0.96833	+0.047
0	825.35	0.97610	+0.071
0	1273.85	0.96118	−0.084
15	1141.17	0.97127	−0.020
15	403.92	0.99014	+0.024
15	873.02	0.97893	+0.075
15	1350.00	0.96585	−0.040
50	455.00	0.99226	−0.010
50	985.33	0.98368	+0.029
50	982.19	0.98296	−0.049
50	1286.60	0.97845	+0.015
50	1513.34	0.97453	+0.004
75	1061.89	0.98557	0.000
75	496.50	0.99327	+0.002

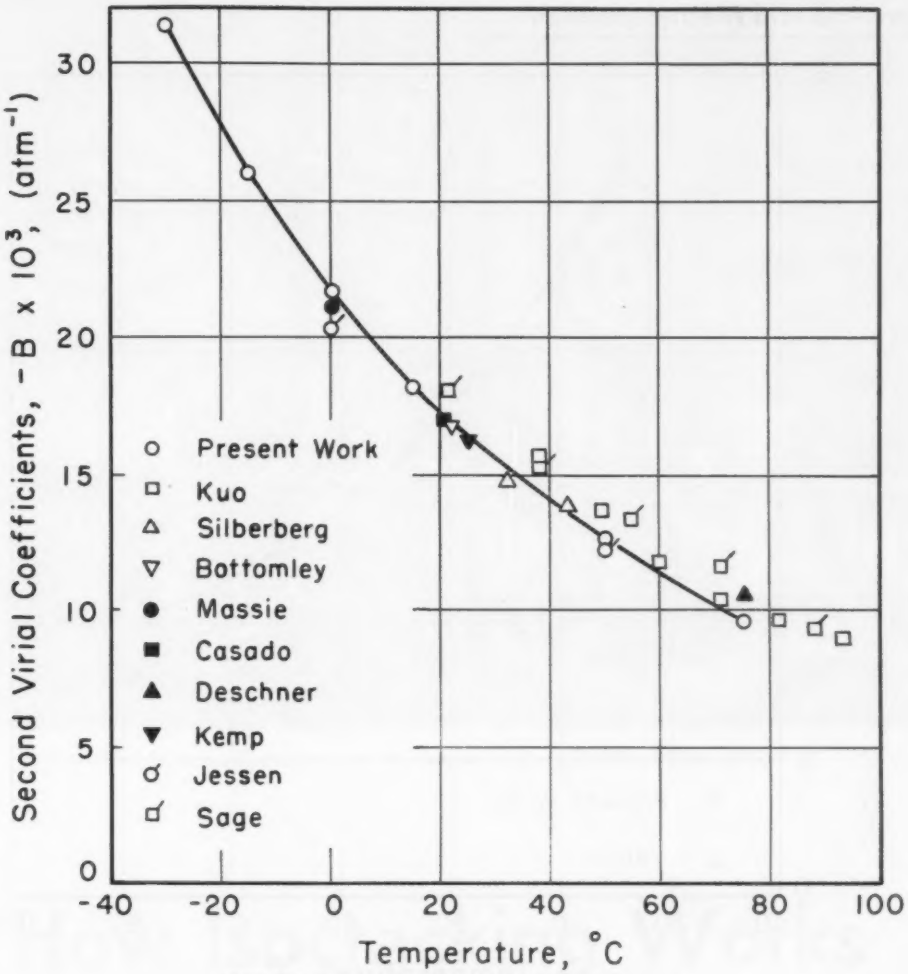

FIGURE 3—Second virial coefficients of propane.

spectrometry were

Methylacetylene	100.0%
n-Pentane	Trace

The reference gas used was argon from the same container used by Pfennig.[8]

Experimental Results. Compressibility factors are presented in Table 2 and in Figures 1 and 2. The results were further treated by fitting them to a virial equation of the form

$$Z = 1 + BP + CP^2 + \ldots$$

for each isotherm.

The virial equation was first simplified to

$$Z = 1 + BP$$

and the value of B, the second virial coefficient for pressure, was evaluated for each isotherm by a method of least mean squares. In the method used the isotherms were forced through the point.

$$Z = 1.0 \text{ at } P = 0$$

and the value of B was found which gave a minimum sum of the squares of the deviation of the points from the linear isotherm. The values determined in this manner are given in Table 1. The deviations from linearity, Table 2, show no definite trend, therefore no significance could be attached to values of C, the third virial coefficient, calculated for this work. It may be concluded from this that the isotherms of propane and methylacetylene are linear within the limits of accuracy of this work and in the range of variables covered.

The maximum error in any particular compressibility factor found in this work may be approximated by summing the probable errors in the terms of Equation 5 plus the error involved in reproducing the balance point. The maximum error thus found is $\pm 0.10\%$, however, from the average of the deviation of the compressibilities from the linear isotherm, $\pm 0.02\%$, it is predicted that the precision of this work is approximately $\pm 0.02\%$ and the compressibility factors are not in error by more than twice this value.

Figures 3 and 4 show the calculated second virial coefficients as compared to values from the literature. In the case of propane the literature values presented here were selected on the bases of precision and range of variables. None of the values given were extrapolated from higher pressures. Excellent agreement with the present work is shown in all cases except in the work of Kuo, whose numerical values are consistently higher. Kuo's work was done on the same apparatus

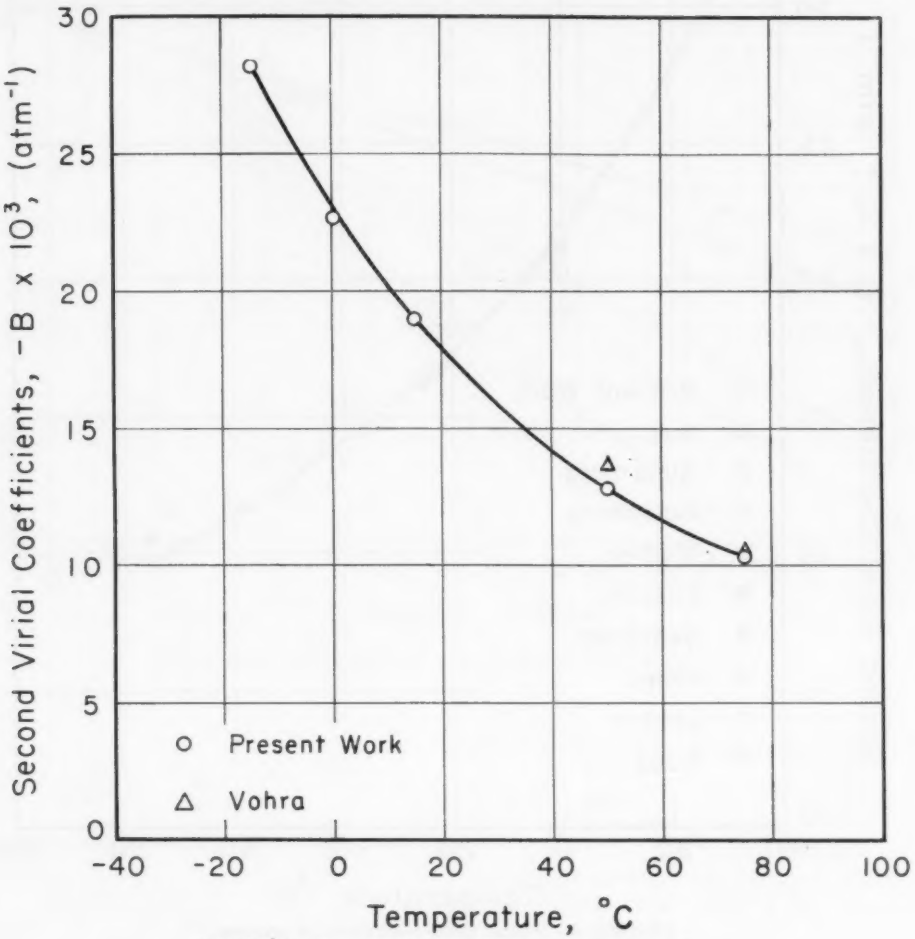

FIGURE 4—Second virial coefficients of methylacetylene.

as the present work, however, Kuo was one of the original investigators using the apparatus, and the technique and equipment have been improved considerably since his work was done.

The only available data on methylacetylene are from Vohra.[11] These values are extrapolated from approximately 7 atm., and are questionable, although the agreement with the present work is remarkable.

NOMENCLATURE

B—second virial coefficient for pressure
C—third virial coefficient for pressure
d —density
M—Molecular weight
n —no. of moles
P—pressure
R—Gas constant
T—absolute temperature
V—Volume
Z—Compressibility factor
Subscripts
r—reference gas
x—gas(es) under analysis

STANDARD VALUES USED

R = 0.0820544 liter atm/gm mole °K
0° C = 273.16° K
Molecular Weights:
Propane = 44.094
Methylacetylene = 40.062

ACKNOWLEDGMENTS

The propane used in this work was donated to The University of Texas by Phillips Petroleum Company of Bartlesville, Okla. Phillips also purified and analyzed the methylacetylene sample. This project is sponsored by the National Science Foundation.

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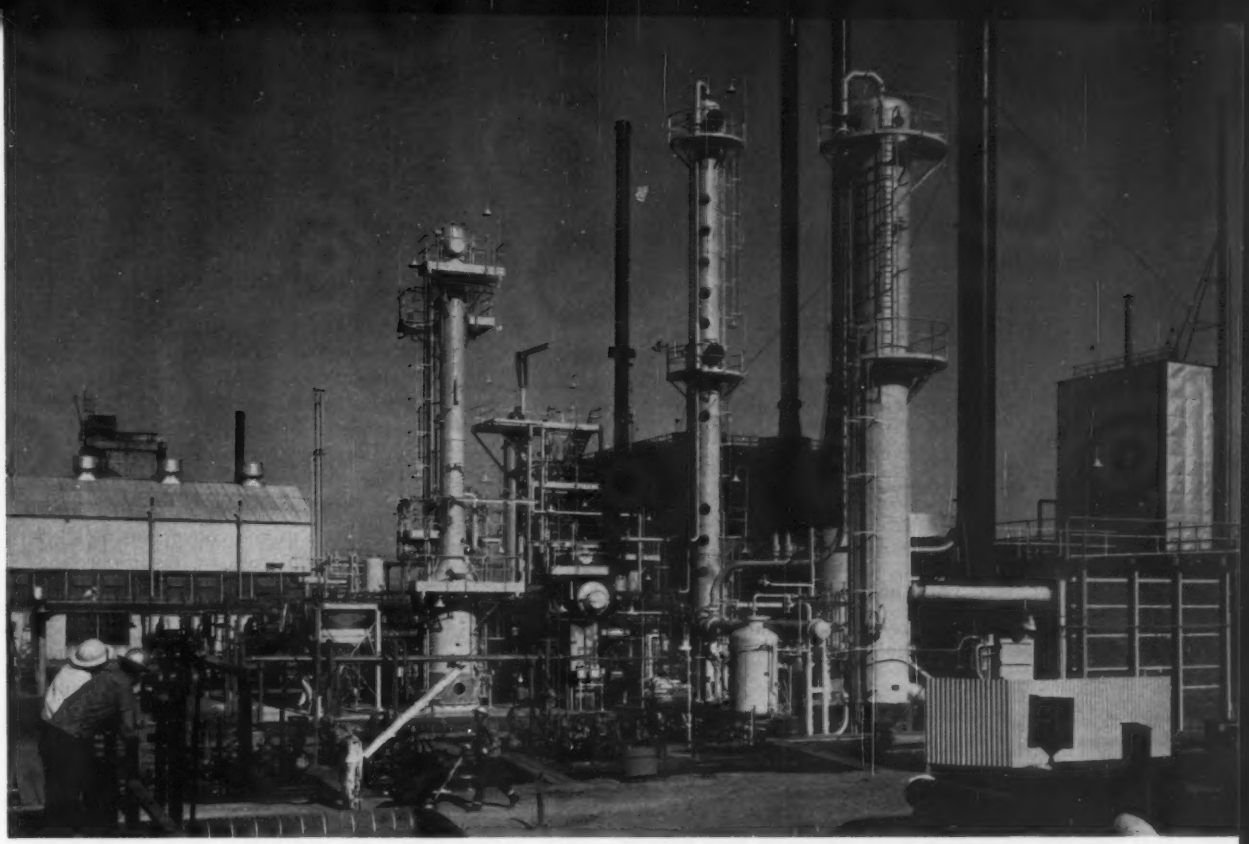

First full-scale Isocracker is at Standard of California's Richmond refinery.

How Isocracking Works

Unusual class-compound reactions dominate the conversion in this new process. They explain the five typical refinery uses for the process

J. W. Scott, H. F. Mason and R. H. Kozlowski, California Research Corporation, Richmond, Calif.

UNUSUAL CLASS-COMPOUND reactions dominate the conversion in Isocracking, a new process recently announced by California Research Corporation.[1, 2, 3, 4] This catalytic hydrocracking process involves reaction conditions that are markedly less severe than those of previous commercial processes of this type. These reactions explain the uses for this process in five typical refinery situations.

Isocracking process flow is similar to that of previous hydrocracking installations, as is evident from Figure 1. However, process conditions are 400-700° F and 500-1,500 psig, in contrast to the 700-1000° F and 3,000-10,000 psig employed previously.[5, 6, 7, 8, 9]

The process is operated nonregeneratively, with a catalyst life of six months or longer. Feed stocks normally require mild hydrogenation before Isocracking.

The Isocracking Reactions. The Isocracking Process and catalyst are designed to allow certain nonequilibrium reactions to dominate conversion. These reactions are complex, yet selective and specific. Results of Isocracking experiments with pure hydrocarbons, and with mixtures rich in a single hydrocarbon class, indicate that the over-all reactions summarized in Table 1 provide the unique products which characterize the process. These reactions take specific and different courses with each hydrocarbon class. The net result is a product distribution governed by mechanistic factors rather than by equilibrium relationships.

Hydrocarbon Classes. The cracking of paraffins occurs by scission to isoparaffin fragments, mainly isobutane and isopentane. Isoparaffins crack much more

How Isocracking Works . . .

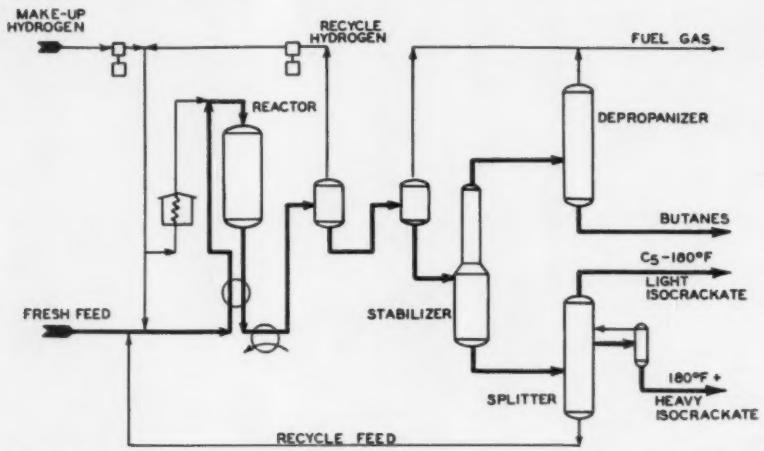

FIGURE 1—Flow scheme for the Isocracking process is similar to other hydrocracking installations.

rapidly than n-paraffins. n-Paraffins undergo isomerization prior to cracking, and it is the rapid cracking of these isoparaffin intermediates which leads to the production of light isoparaffins.[6] Because of the low temperatures used in Isocracking, it is frequently observed that a substantial portion of the residue of large paraffin molecules, which remain after splitting off light isoparaffins, also is isomerized. Disproportionation of paraffins also occurs, resulting in a greater yield of light isoparaffins than would be anticipated by simple scission.

An example of Isocracking a C_7-C_{10} paraffin stream is given in Table 2. The large proportion of isoparaffins, and the very small amount of methane and ethane formed, are typical.

Isocracking monocyclic naphthenes occurs by a dealkylation process which results in production, mainly, of isobutane and lower molecular weight naphthenes.[10] Ring opening reactions are relatively unimportant for monocyclic naphthenes. As a consequence, conversion is accomplished with very high conservation of ring structure. In general, bicyclic naphthenes follow a reaction path which involves opening one ring to give an alkyl-substituted monocyclic naphthene. This then reacts rapidly according to the route previously described.

An example of Isocracking a naphthene-rich stock is shown in Table 3. It can be observed that (a) a large number of lighter naphthenes are formed, with a very high molal yield of rings, (b) the proportion of cyclopentane to cyclohexane isomers is largely on the cyclopentane side of equilibrium, and (c) the ratio of iso-to-normal paraffins is extremely high.

Much of the conversion of alkylbenzenes occurs by disproportionation. This, and subsequent very specific reactions of the poly-substituted alkylbenzene intermediates, results in demethylation without the formation of methane. Methyl fragments and ethyl fragments are incorporated in the light isoparaffin products. It is interesting that alkylbenzenes with side chains containing more than three carbon atoms tend to dealkylate rapidly to the corresponding paraffin and aromatic. Alkylbenzenes containing 10 or more carbon atoms are converted by a dealkylation process which produces mainly butanes and lower molecular weight alkylbenzenes, even when the alkyl groups are methyl or ethyl.[10] A small amount of conversion occurs by way of hydrogenation to naphthenes. These then react as discussed previously.

Benzonaphthenes react primarily by opening the saturated ring to produce an alkylbenzene. This then follows the reaction paths described above. Naphthalenes are converted through hydrogenation of one of the rings to give benzonaphthenes, which react as above.

An example of Isocracking a C_{10}-C_{13} aromatic mixture is given in Table 4. This shows production of large amounts of C_8 and C_9 aromatics and very small amounts of methane and ethane. The high degree of conservation of ring structures is typical. The lower iso-to-normal ratio here observed in the butanes, and the relatively

TABLE 1—Isocracking C_{10}-C_{12} Hydrocarbons—Major Reactions and Products

Major Reactions	Predominant Final Products
Paraffins	
Isomerization	Light Isoparaffins
Scission	
Naphthenes	
Isomerization	C_6—C_8 Cyclopentanes
Hydrodealkylation	Light Isoparaffins
Dinaphthenes	
Ring Opening	Similar to Naphthenes
Isomerization	
Hydrodealkylation	
Alkylbenzenes	
Isomerization	C_8—C_9 Alkylbenzenes
Disproportionation	Light Isoparaffins
Hydrodealkylation	Light Cycloparaffins
Hydrogenation	
Benzonaphthenes	
Ring Opening	Similar to Alkylbenzenes
To Alkylbenzenes	
Naphthalenes	
Hydrogenation	Similar to Alkylbenzenes
To Benzonaphthenes	

TABLE 2—Isocracking C_7-C_{10} Paraffins

Feed: 205-350° F Raffinate from a Catalytic Reformate (77% P, 20% N, 3% A)

Product Yields[A]:	Weight Percent	Volume Percent
C_1	0.1	....
C_2	0.5	....
C_3	13.2	....
iC_4	27.5	35.8
nC_4	10.7	13.4
iC_5	27.2	31.5
nC_5	4.3	5.0
iC_6	12.4	13.5
nC_6	1.5	1.6
MCP	2.0	1.9
CH	0.6	0.6
C_7's	2.3	2.5
TOTALS, C_1+	102.3	....
C_4+	.....	105.8

[A] Based on fresh feed to the Isocracker during extinction recycle operation at about 75% per pass conversion to products boiling below 205° F.

high yield of propane, are a consequence of mechanistic factors connected with the structure of some of the aromatics in this feed. Many other aromatic-rich mixtures show a more characteristic high iso-to-normal ratio for the light paraffins.

Hydrocarbon Mixtures. Applying the Isocracking process to refinery mixed hydrocarbon streams gives results which are, to a first approximation, consistent with the foregoing hydrocarbon-class reactions. This does not mean that interactions are unimportant. However, when molecular weight and the proportions of the hydrocarbon classes are considered properly, Isocracking results can be predicted.

A summary of the product distribution obtained from pilot plant Isocracking of three cracked middle distillate streams is given in Table 5. These results were obtained while operating with extinction recycle of unconverted feed under commercial Isocracking conditions. The pressure was about 1200 psig and the temperature was appropriate for the catalyst activity at the time the data were taken. The data for heavy naphtha feed illustrate Isocracking for maximum octane improvement or for gasoline volatility control. The data for light cycle oil and light coker distillate feeds exemplify Isocracking for fuel oil reduction.

The general fractionation scheme for Isocracked products is to separate: (1) a fuel gas stream, (2) an isobutane rich fraction, (3) a C_5-180°F light Isocrackate, and (4) a 180°F+ heavy Isocrackate. We will describe these products, discuss the effect of feed properties upon their character, and compare them with similar boiling range products encountered in current refining operations.

The small amount of fuel gas produced by Isocracking is principally propane. Methane yields average 0.01 weight percent, and ethane yields generally range from 0.2-0.5 weight percent. Propane yields increase as feed molecular weight is decreased. Propane yields also show a moderate response to the structure of aromatic components in the feed.

The yield of butanes ranges from 7-15 weight percent, and tends to be higher with low molecular weight feeds. The proportion of isobutane in this fraction is typically greater than that produced by isomerization processes, as is shown in Table 6.

The C_5-180°F light Isocrackate yield generally ranges from 25 to 35 volume percent to feed. The unusual properties of this fraction are evident from Tables 7 and 8. These properties are little affected by feed character.

Table 7 presents molecular analysis of this stream with similar analyses of C_5-C_6 fractions from a low temperature isomerization of light straight run gasolines and from catalytic reforming of a cracked naphtha. The isomerization of light straight run gasoline stocks is practiced on lighter feeds than ordinarily are fed to Isocracking. In fact, Isocracking is not an isomerization process for such feeds. The light Isocrackate and isomerizate are similar, however, in that both are saturated and

TABLE 3—Isocracking C_{11}-C_{14} Naphthenes
Feed: 400-600° F. Naphthenic Gas Oil Fraction (84% Naphthenes)

Product Yields[A]	Weight Percent	Volume Percent
C_1	0.00	....
C_2	0.03	....
C_3	0.8	....
iC_4	9.4	14.1
nC_4	0.7	1.0
iC_5	8.3	11.2
nC_5	0.04	0.05
iC_6	5.1	6.5
nC_6	0.2	0.3
MCP	2.9	3.2
CH	0.2	0.2
C_7+ Paraffins	75.2	18.8
C_7+ Naphthenes		62.0
TOTALS C_1+	102.9	....
C_4+	....	117.3

[A] Based on fresh feed to the Isocracker during extinction recycle operation at about 60% per pass conversion to products boiling below 400° F.

TABLE 4—Isocracking C_{10}-C_{13} Aromatics
Feed: 350-480° F Catalytic Reformate (95% Aromatics)

Product Yields[A]	Weight Percent	Volume Percent
C_1	0.01	....
C_2	0.6	....
C_3	4.4	....
iC_4	3.8	6.2
nC_4	4.4	6.8
C_5+	89.5	100
TOTALS C_1+	102.7	....
C_4+	....	113.0
C_5+ Component Breakdown		
Benzene		1
Toluene		9
C_8 Aromatics		24
C_9 Aromatics		28
C_5+ Naphthenes		24
C_5+ Paraffins		14

[A] Based on fresh feed to the Isocracker during extinction recycle operation at about 60% per pass conversion to products boiling below 350° F.

TABLE 5—Isocracking Yields From Cracked Middle Distillates

Crude Source	Heavy Cracked Naphtha California	Catalytic Cycle Oil California	Light Coker Distillate California
Charge Stock Inspection[A]			
Gravity, °API	36.7	29.5	35.1
Aniline Point, °F	88.5	88.0	124.0
ASTM D 158, °F			
ST	370	398	348
10%	376	440	416
50%	383	472	474
90%	405	507	553
EP	450	566	603
Composition, LV%			
Aromatics	43	54	29
Saturates	57	46	71
Isocracking Yields[B]			
Recycle Cut Point	360 °F	400 °F	400 °F
Dry Gas, Wt. %			
Methane	0.01	0.01	0.01
Ethane	0.6	0.25	0.22
Propane	3.6	3.4	3.8
Liquids, Vol %			
Isobutane	14.0	10.5	13.4
n-Butane	5.8	6.3	6.2
C_5-180 °F	26.3	26.8	27.9
180 °F +[C]	67.7	73.7	68.4
Over-All Yields to Raw Feed Liquids, Vol. %			
Isobutane	14.0	10.6	14.0
n-Butane	6.0	7.0	6.7
C_5+	94.3	101.6	100.5
H_2 Consumption, SCF/B			
Isocracking	1230	1340	1050
Over-All	1450	1900	2100

[A] After mild hydrogenation.
[B] Extinction recycle below recycle cut point.
[C] Liquid yield of 180° F to recycle cut point.

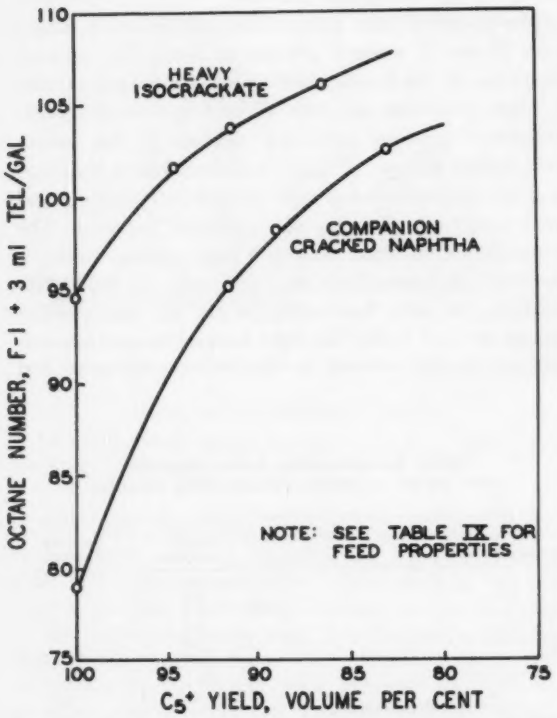

FIGURE 2—Reforming yields for heavy isocrackate are higher than those of a companion cracked naphtha.

both have F-1 and F-2 leaded octane numbers of about 100.

Comparison of the isomerizate with light Isocrackate nevertheless offers a convincing insight into the non-equilibrium nature of the latter product. Isocracking yields a higher proportion of isoparaffins than does low temperature isomerization. On the other hand, the methylcylopentane-to-cyclohexane ratio in the Isocrackate is comparable to that from high temperature isomerization. This latter anomaly contributes importantly to the octane advantage of the light Isocrackate since the F-1 octane number of methylcyclopentane (plus 3 ml TEL/gal is 105.3, while that for cyclohexane is only 97.4.

The composition of the light reformate on Table 7 is typical of light products produced by hydrocracking over reforming catalysts. The hydrocarbons contained therein are usually present in proportions close to thermodynamic equilibium at the reforming conditions employed. Octane numbers are, consequently, far below those for the corresponding fractions from either Isocracking or low temperature isomerization.

Table 8 compares the quality of C_5-180°F light Isocrackate with the quality of similar boiling fractions from light straight run, light thermal cracked, light catalytically cracked, and light catalytically reformed gasolines. The leaded octane number of the light Isocrackate is about 100 by both the research and motor methods. Thus, it possesses the highest road octane number of any of the light naphthas shown. Only catalytically cracked naphtha possesses an F-1 octane number as high as that of the light Isocrackate. The high olefin content and resultant high sensitivity of catalytically-cracked naphtha place it, however, at a considerable disadvantage from a road octane viewpoint.

The properties of the heavy Isocrackate (180°F+ synthetic product) are greatly dependent upon feed character. Ring structures appear in the product in almost theoretical molal yield. An aromatic feed will produce an aromatic heavy Isocrackate. A paraffinic feed will produce a paraffinic heavy Isocrackate. Despite appreciable concentrations of normal paraffins in several middle distillate feeds, it was observed that normal paraffins were almost completely absent from the heavy Isocrackates derived therefrom.

The composition of a typical 180-360°F heavy Isocrackate is shown in Table 9 together with that of a similar boiling range reformer feed. The latter was prepared from the same refinery stream as the Isocracker feed. It is evident that the heavy Isocrackate has an advantage due both to its high ring content and its high octane number. These differences are reflected in more favorable yield-octane relationships after reforming.

Figure 2 shows that the yield-octane relationship for platinum catalyst reforming of the heavy Isocrackate is

TABLE 6—Isoparaffin Content of Butane Fractions From Isocracking and From Butane Isomerization

Process	Isobutane Content of C_4's, Percent
Isocracking	
Heavy Cracked Naphtha	71
Light Catalytic Cycle Oil	62
Coker Distillate	68
Straight Run Gas Oil	68
Butane Isomerization	
Low Temperature $AlCl_3$ [A]	50—60
Moderate Temperature Hydroisomerization[B]	40—60
Thermodynamic Equilibrium[B]	
400° F	60
700° F	44

[A] Samaniego, J.A., Petroleum Refiner **36**, 223 (September 1957).

[B] Bloch, H.S.; Donaldson, G.R.; Haensel, V.; Div. of Petroleum Chem., 135th Meeting, ACS, Boston, Mass., April 1959.

TABLE 7—Comparison of Typical C_5-C_6 Fractions From Isocracking, Catalytic Reforming, and Isomerization

	Isocracking [B]		Platinum Reforming	Low Temperature Isomerization [A]	
FEED	Heavy Cracked Naphtha	Light Catalytic Cycle Oil	360 °F− Cracked Naphtha	Light Straight Run	
Crude Source	California	California	California	Louisiana	Arabia
Components, Vol. %					
n-Pentane	4.5	4.1	19.1	4.8	7.1
i-Pentane	45.6	38.6	20.9	23.1	33.3
n-Hexane	1.6	1.7	14.9	4.4	4.1
i-Hexanes	32.2	38.1	33.6	43.3	46.9
Cyclopentane	...	...	...	1.8	0.1
Methylcyclopentane	13.2	12.3	1.9	2.2	0.9
Cyclohexane	0.1	1.9	1.0	15.6	6.6
Benzene	2.8	3.3	8.6	4.8	1.0
	100.0	100.0	100.0	100.0	100.0

[A] K.P. Tanneau et. al., Fifth World Petroleum Congress, Section III, Paper 3, June 1959.

[B] Yields of C_5-C_6 fractions were 26.3 Vol. % of heavy naphtha, and 24-27 Vol. % of light cycle oil Isocracker feed.

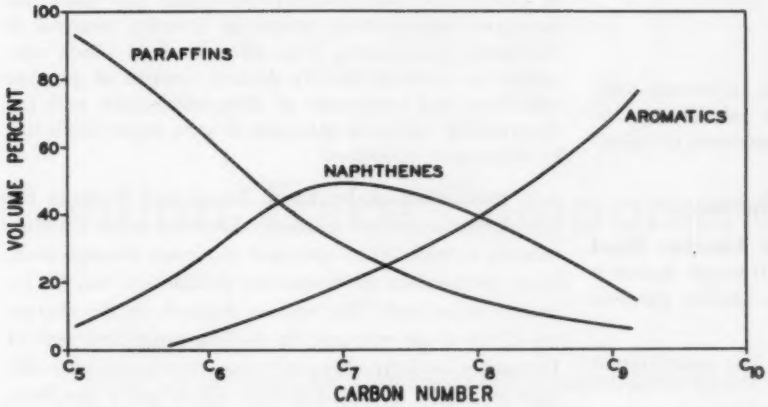

FIGURE 3—Isocracker product distribution for heavy cracked naphtha feed explains octane advantage, when compared with typical reformer charge stock.

markedly above that for the companion reformer feed. Some of this advantage may be attributed to its higher ring content and higher initial octane number. However, an advantage of the order of 1-3 octane numbers is obtained above what would be expected from a reformer charge stock of the same component analysis, octane number, and boiling range. We attribute this additional advantage to the unusual distribution of hydrocarbon types in the heavy Isocracked naphtha. As is evident in Figure 3, none of the hydrocarbon classes is evenly distributed by carbon number throughout the boiling range of this stock. The paraffins present tend to be in the lower boiling fractions where their octane numbers as a class are highest. Also, the concentration of n-paraffins is very low. Naphthenes tend to accumulate in the C_7-C_8 carbon number region. Subsequent reforming, therefore, produces toluene and xylenes, which are among the highest octane number aromatic components in gasoline.

Varying Operation to Control Product Distribution. The yields of these unusual product streams may be varied within wide margins. Figure 4 illustrates that large variations in recycle still cut point can be imposed without significant effect on over-all C_4+ liquid yield. As the cut point is reduced, the relative amounts of butanes and light Isocrackate are increased, with a corresponding decrease in the amount of heavy Isocrackate reformer feed.

Refinery Use of the Reactions. Typical refinery uses for the Isocracking reactions are listed below. Most of these can be understood in the light of the previous

TABLE 8—Comparison of Light Isocrackate With Typical C_5-180° F Boiling Range Gasoline Components

	Light Straight Run		Light Thermal Cracked	Light Catalytic Cracked	Light[A] Reformed	Light Isocracked
	East Texas	California				
Olefin Content, %	Nil	Nil	45	80	Nil	Nil
ASTM Octane Numbers						
F-1 Plus 3 ml TEL/GAL.	86.0	91.5	96.2	100.0	92.0	100.0
F-2 Plus 3 ml TEL/GAL.	86.0	91.0	83.7	85.0	91.0	100.6
Sensitivity	0.0	+0.5	+12.5	+15.0	+1.0	−0.6

[A] C_5—180 °F Cut from reforming a typical California mixed naphtha to 101 F-1 leaded octane number.

TABLE 9—Comparison of Reformer Feed Properties

	Heavy Isocrackate[A]	Hydrofined Cracked Naphtha[B]
Boiling Range, °F.	180—360	170—360
Component, Vol. %		
Paraffin	22.7	40.4
Naphthene	39.8	36.1
Dinaphthene	2.3	5.0
Alkylbenzene	35.2	18.0
Benzonaphthene	....	0.5
Alkylbenzene Breakdown		
C_6	0.3	0.2
C_7	5.2	1.7
C_8	12.6	5.9
C_9	15.7	8.2
C_{10}	1.4	2.0
Octane Number		
F-1 Clear	84.6	59.7
F-1 + 3ml TEL/GAL	94.5	78.9
ASTM Distillation D 86		
ST	218	159
10%	241	241
50%	275	287
90%	329	327
EP	350	377

[A] From Isocracking 360° F+ Portion of a whole hydrofined cracked naphtha.

[B] The 360° F− Portion of the same whole hydrofined cracked naphtha.

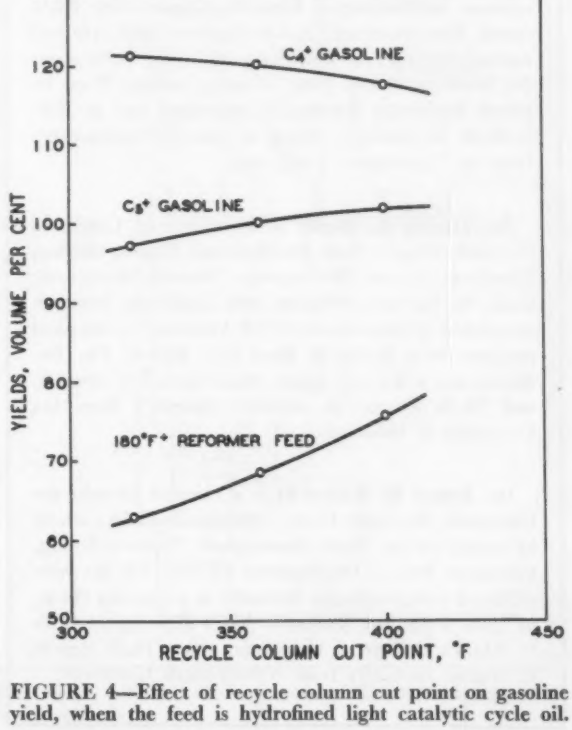

FIGURE 4—Effect of recycle column cut point on gasoline yield, when the feed is hydrofined light catalytic cycle oil.

How Isocracking Works . . .

discussion of class-compound reactions. In several cases, comments are added to indicate the relationship between Isocracking and other refining processes or operations:

1. **Production of Isobutane and Isopentane**

2. **Production of 100 Octane Light Gasoline Blend Stock.** The low sensitivity of this fraction makes it especially attractive for premium quality gasoline blends.

3. **Gasoline Quality Improvement.** The combination of Isocracking and catalytic reforming has many advantages: reduction in reforming severity, removal of the heavy constituents from reformer feed which contribute to catalyst activity decline, control of gasoline volatility, and separation of dehydrogenation and hydrocracking reactions into two process steps which can be separately optimized.

4. **Production of Jet Fuels.** Isocracked products are free of impurities and possess reduced aromatic contents relative to feed. When operated on a once through basis, large proportions of Isocracker production can be included in jet fuels. The amount depends on the character of the crude run and the boiling range and type of Isocracker feed. An alternative way to prepare kerosene-type jet fuel is to Isocrack cycle oils or coker distillates to produce new gasoline stock, and thus release paraffinic heavy straight run components from the gasoline pool to kerosene jet. When Isocracking is used in this second way, increased jet fuel production is accompanied by a significant octane improvement in the gasoline pool.

5. **Reduction of Fuel Oil.** Isocracking can be used as incremental cracking, releasing existing catalytic cracking capacity for processing additional heavy gas oils or for increased recycle of heavy cycle oils. The processes compliment each other. Catalytic cracking is most effective with heavier stocks, while Isocracking handles lighter, refractory stocks more efficiently.

Commercial Operations. The first commercial Isocracking plant was placed in service in mid-1959 at the Richmond, California, Refinery of Standard Oil of California. Its performance is in complete accord with laboratory and pilot plant results.

This plant has operated both for octane improvement and for fuel oil reduction without significant change in the Isocracking equipment. Such unusual versatility is due to the fact that the class-compound reactions described herein all can be conducted in simple general purpose equipment. The Isocracker itself can be adapted to each service discussed above with only minor adjustments in feed rate. Feed preparation and product fractionation will of course vary, depending upon the specific case.

About the Authors

Scott Mason Kozlowski

J. W. Scott is supervisor of petroleum process development for California Research Corporation, Richmond. After receiving his B.S. degree in chemistry and engineering from the University of California, he spent five years in World War II army service. Then he joined California Research Corporation and in 1951 received his master's degree in chemical engineering from the University of California.

Dr. Harold F. Mason is supervisor of California Research Corp.'s New Development Projects Group, Petroleum Process Development Division, Richmond, Calif. He has been affiliated with California Research as a research chemist since 1954. Previously a chemical engineer with Rohm & Haas Co., Bristol, Pa., Dr. Mason has a B.Ch.E. degree from Cornell University, and Ph.D. degree in physical chemistry from the University of Wisconsin.

Dr. Robert H. Kozlowski is a research chemist for California Research Corp., Richmond, Calif., where he works in the New Development Projects Group, Petroleum Process Development Division. He has been affiliated with California Research as a research chemist since 1955. Dr. Kozlowski has a B.S. degree from St. Mary's College of California, and a Ph.D. degree in organic chemistry from Northwestern University.

ACKNOWLEDGMENT

We acknowledge the many contributions of our colleagues at the California Research Corporation to the development of the Isocracking process.

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Confirm Trace Component Identity

Here's a method for finding trace components in an operating column overhead which is based on tray efficiency for the trace component separation

H. W. Martin
Monsanto Chemical Company
Texas City, Texas

IMPURITIES WHICH were not anticipated in the original design of a plant frequently appear in a distillation system. These trace components often cause major product quality or specification problems. The first step toward a permanent problem solution is the identification of the compound which is causing the trouble.

This identification is traditionally a Research task, and is usually a difficult job. However, the Engineering Department has another source to confirm tentative Research identification and analyses of the trace component: *plant data.*

The method developed is applied to plant operating columns, and is based on an estimated tray efficiency for the trace component separation. The procedure then calculates the vapor-liquid equilibria required to explain the measured column separation of the trace component. From this calculated vapor-liquid equilibria, the proposed identity of the compound can either be confirmed, or a new one put forth.

By using this method before designing additional purification facilities, two serious errors can be avoided: (1) the use of ideal system assumptions where they are not valid; and (2) the use of pure component equilibrium data, where the pure component is not correctly identified.

Perhaps one example of the success of the method, in spite of the approximations involved, will illustrate the potential of the procedure.

Figure 1 illustrates one of the columns in a monomer plant in Texas City. This column removes heavy ends from the raw monomer in preparation for final product processing.

Compound A is a trace impurity present in the system. Compound A has been identified and is analyzed by mass spectrometer. A reasonable reaction source has been proposed. A small amount of Compound B is also present, and this presence is pertinent to this example. Both A and B should behave as light ends in this column.

Compound A contributes to one of the monomer specification problems. As part of a program to find ways

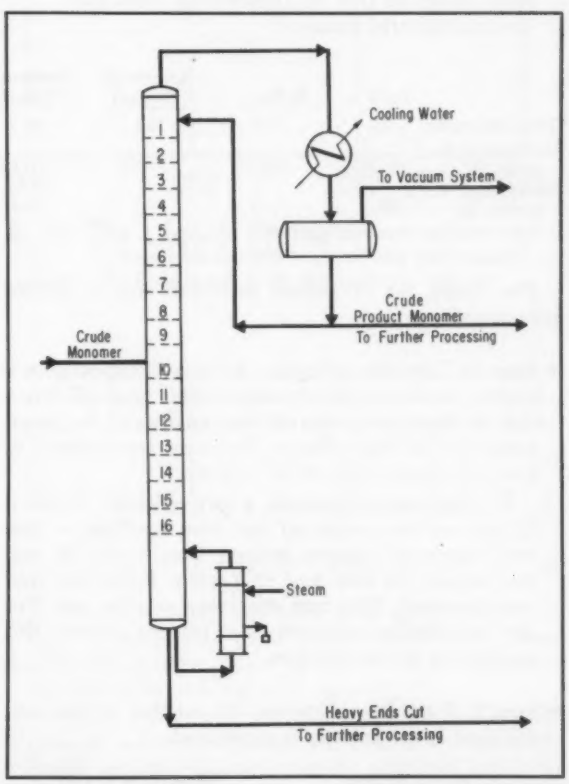

FIGURE 1—This is the monomer distillation column used in the example.

Confirm Trace Component Identity . . .

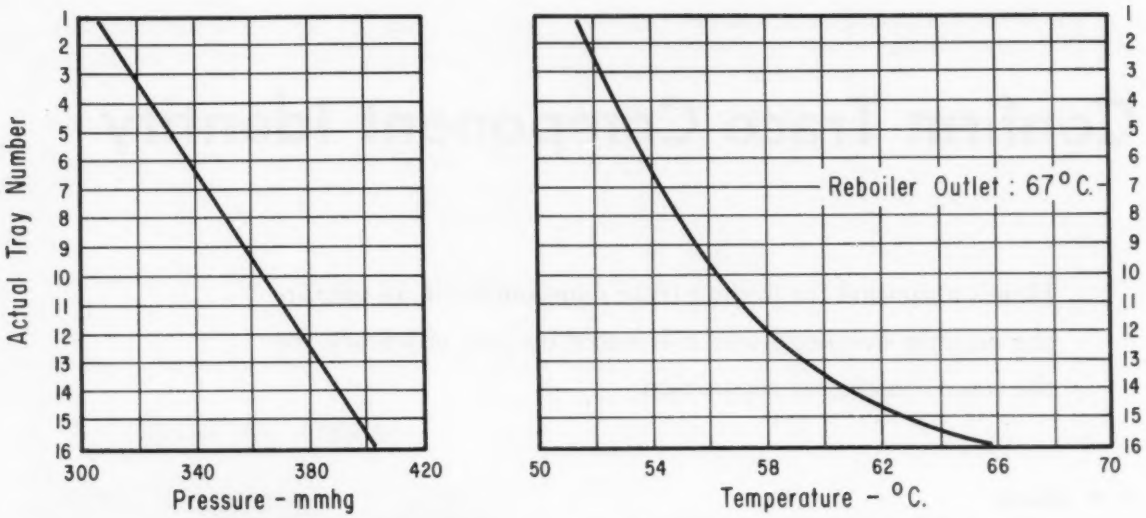

FIGURE 2—These are the temperature and pressure profiles used in the example column.

to minimize A in the monomer, the separation in this column was investigated.

Known: Number of actual trays: 16 plus reboiler. Feed enters on tray 10 (numbering from top).
Column material balance:

	Feed	Reflux	Overhead Product	Bottoms Product
Total moles/hr.	206	274	168	38
Compound A, mole %[1]	.0403	.0400	.0400	.0410
Compound A, moles/hr	.083	.110	.067	.016

[1] By mass spectrometer analysis.

Temperature and Pressure profiles: see Figure 2.

For clarity, the calculation procedure will be divided into steps:

- **Step 1:** The tray efficiency for the Compound A—system separation is estimated. This tray efficiency may be based on a conventional analysis of the major separation of the column, literature correlations, or past experience with similar systems.

  For the example column, a tray efficiency of about 50 percent was estimated and then modified to give even-numbered column sections. Specifically, 44 percent above the feed and 43 percent below the feed were assumed. This tray efficiency may be low. For the non-ideality indicated ($\gamma < 1.0$; see below), this assumption is conservative.

- **Step 2:** From this efficiency, the number of theoretical trays in the column is established.

Example Column Section	Theoretical Trays
Above Feed	4.0
Below Feed	4.0 (including reboiler)

- **Step 3:** The vapor and liquid loads on each theoretical tray are calculated.

  Although the feed to the example column is subcooled, the degree of subcooling is small, and was neglected. Equimolal overflow also is not precisely valid, but is a good assumption in this column. Hence:

Column Section	V, moles/hr	L, moles/hr
Above Feed	442	274
Below Feed	442	480

- **Step 4:** The reflux ratio (L/V), the temperature, and and the pressure on each theoretical tray are determined and tabulated. The vapor pressure of Compound A on each theoretical tray, and the terminal column compositions of Compound A are also tabulated.

  For the example column:

Theo. Tray Number	L/V	Temp., °C	Press., mm Hg.	Vapor Press., Compound A mm Hg.
1	.620	51.6	310	630
2	.620	52.6	325	660
3	.620	53.7	340	680
4	.620	54.7	355	700
5	1.086	57.0	370	765
6	1.086	60.0	385	850
7	1.086	64.2	400	975
8	1.086	67.0	410	1070

Y_O = .040%
X_R = .040%
X_B = .041%

The procedure now becomes trial-and-error to solve for the vapor-liquid equilibria required to explain the indicated separation. The method as developed uses the activity coefficient (γ) to express the total degree of ideality in the system.

- **Step 5:** An average activity coefficient (γ_{avg}) for

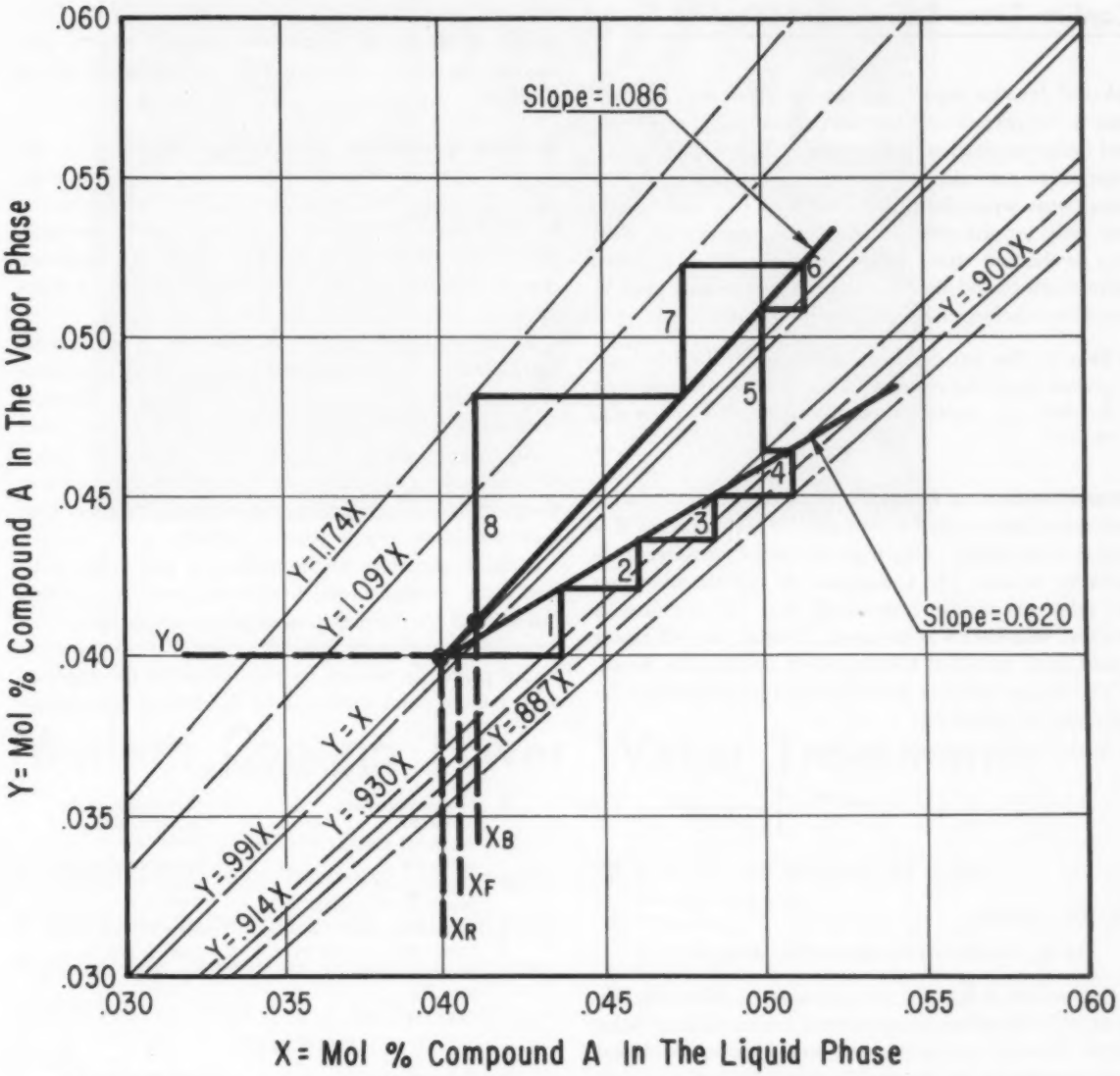

FIGURE 3—Shows an enlarged section of the graphical solution for Compound A in the example column.

Compound A is assumed. In the example column, a γ_{avg} of 0.45 closed the column balances.

- **Step 6:** The relationship for K of Compound A on each theoretical tray is calculated by the usual

$$K_n = \frac{\gamma_{avg}\,(vp_n)}{\pi_n} \qquad (1)$$

For the example column:

Theoretical Tray	K of A at $\gamma_{avg} = 0.45$
1	.914
2	.914
3	.900
4	.887
5	.930
6	.991
7	1.097
8	1.174

- **Step 7:** Solution of the usual equilibrium and material balance relationships for Compound A in the column is attempted. For the conventional column:

$$y_n = K_n x_n \qquad (2)$$

$$y_{n-1} = \frac{L}{V} x_n + \frac{D}{V} x_D \text{ (above the feed)} \qquad (3)$$

$$y_{n-1} = \frac{L}{V} x_n - \frac{B}{V} x_B \text{ (below the feed)} \qquad (4)$$

This step has usually been done graphically, generally starting at the top of the column. Log-log paper frequently has been used where the trace component concentration covers a wide range.

Figure 3 illustrates the graphical solution for the example column. Note that the area shown is an enlarged section of a conventional graphical presentation.

Figure 3 shows that the feed tray is not properly

selected for the separation shown. However, the feed tray is the correct one for the primary monomer-heavy end design separation of the column. Improper feed tray location is generally one of the characteristics of trace component separations, since the feed tray will be correct only for the design and similar separations. Feed tray evaluation must follow proper trace component identification, and the effect on all separations must be considered before the feed tray is changed.

- **Step 8:** The procedure, beginning at Step 5, is repeated until the column balances close at some γ_{avg}. In this case, again, the calculation produced a γ_{avg} of 0.45.

Interpretation of Example Results. The calculation procedure has revealed a very non-ideal Compound A—system relationship. This high degree of non-ideality is unlikely, because (1) Compound A and the monomer are relatively similar compounds and (2) a relatively low tray efficiency was assumed. A higher tray efficiency would have increased the degree of non-ideality found.

The boiling point of the compound indicated by these data can be estimated:

At the boiling point, y = x, and:

$$\left[K = \frac{y}{x} = 1 = \frac{\gamma_{avg}\,(vp_A)}{760}\right] \text{ at the b.p.} \qquad (5)$$

$$[vp_A = 760/\gamma_{avg}] \text{ at the b.p.} \qquad (6)$$

For the example:

$$vp_A = 760/0.45 = 1690 \text{ mm Hg at the b.p.}$$

Compound A has a vapor pressure of 1690 mm Hg at 81° C. Therefore, a compound have a boiling point of 81° C and producing the same mass spectrometer peak may have been reported as Compound A.

Note the two assumptions in this calculation: (1) the true compound vapor pressure curve is parallel to Compound A's in the temperature range between column operation and the calculated boiling point; and (2) the true compound is ideal in the system.

Laboratory work is required to resolve the true identity of Compound A. A literature survey revealed the following possibilities, all of which produce the same mass spectrometer peak (used for the analysis of A) and have a reasonable hypothetical source reaction:

Compound	B.P., °C
A	56
A′	96
A″	250

A″ is the addition product of Compound A and Compound B (the other cited light end in the system). The impurity reported as Compound A, then, may be some mixture of these three compounds.

If Compound A′ is primarily present, additional distillation equipment may solve the problem. If Compound A″ is present, a chemical removal system, promoting the reaction of A and B, coupled with existing distillation equipment, may solve the problem.

General Comments. One obvious limitation of the method is that, over large concentration ranges, an average γ is a poor assumption. By using tray sample results, however, small sections of the column can be analyzed, minimizing this difficulty. Further, experience has shown that this limitation may not be a severe one in many cases.

An advantage of the procedure is that, in any column "pinch" where the equilibrium and operating lines come close together, the assumption of tray efficiency becomes relatively unimportant, and the method becomes exact.

Another advantage of the method is that the location of peak concentrations in the column are uncovered in the procedure. These peaks may lead to drawoffs of concentrated impurities to solve a problem.

A third advantage of the method is that "class analyses" (for example, total basicity as some compound) can be used for the initial column material balance. The procedure can then be applied to help identify the compound primarily present by calculation of the approximate boiling point indicated by the column separation.

NOMENCLATURE

B	bottoms product, moles/hr	x	concentration in liquid phase, mole frac.
D	overhead product, moles/hr	y	concentration in vapor phase, mole frac.
K	vapor-liquid equilibrium constant	γ	activity coefficient
L	liquid flow, moles/hr	π	total pressure, mm Hg
V	vapor flow, moles/hr		
vp	vapor pressure, mm Hg		

SUBSCRIPTS

A	Compound A	n, n — 1	theoretical tray number
avg	average	O	overhead vapor
B	bottoms product	R	reflux
D	overhead product		
F	feed		

About the Author

Howard W. Martin is a senior chemical engineer for Monsanto Chemical Co., Texas City, where he works on process improvement of present facilities, economic evaluations, and design of new plant facilities. He has a B.S. degree in chemical engineering from The Rice Institute and a M.S. degree in chemical engineering from the University of Wisconsin. He has been in Monsanto's Plastics Division, Texas City, for about seven years, the time being evenly split between the Technical Services and Engineering Departments.

Take a look at . . .

Modern Cooling Tower Water Treatments

A high pH will stop corrosion but deposits would foul equipment. A low pH will stop deposits but corrosion would be serious. Follow these steps for a balanced treatment

Ralph P. Gulley
Gulf Oil Corporation, Port Arthur, Texas

THE CONCENTRATION of solids produced in conventional cooling tower systems create problems of deposition and corrosion not present with once-through operations. Further, the corrosion potential of the recirculating water is higher because it becomes saturated with air in passing over the cooling tower. For these reasons, treatment of circulating water is usually required for efficient operation. Fortunately, the use of recirculating systems also makes treatment easier because the chemicals needed are reduced to that amount lost in the blowdown.

Approaches. There are a number of basic approaches to controlling deposition and corrosion in recirculating cooling tower systems. These are as follows:

1. No control over water condition is attempted in the recirculating system.
2. Both pH and blowdown are controlled in the recirculating system.
3. Three factors, pH, blowdown, and chemical treatment are controlled in the recirculating system.

Note that these approaches are arranged in increasing order of cost and complexity.

The conditions under which a cooling tower system operates determines the best approach required. Such conditions as availability and quality of makeup water, type of heat transfer equipment served, range of temperatures at which heat is rejected to cooling water, etc., enter into the choice of approach.

When using approach (1), the pH of the circulating water is determined by the characteristics of the makeup water. The blowdown is the water loss resulting from windage and other uncontrolled losses from the system. This approach is applicable where heat transfer and corrosion protection are not critical or where the size of the installation does not warrant increased attention.

When using approach (2), the pH and blowdown are controlled to give a slight scaling tendency to the circulating water. Experience and such guides as Langlier's Saturation Index are used to develop a film of scale sufficient to reduce corrosion without hindering heat transfer.[1] This approach is applicable where a narrow band of heat transfer temperatures is involved, where heat transfer is not critical, or where transfer equipment can be cleaned frequently.

When using approach (3), water treating chemicals are added to the circulating water, in addition to the pH and blowdown control used in approach (2), to

give adequate corrosion and deposition protection. This approach is applicable where a wide band of heat transfer temperatures are involved, where heat transfer is critical, where extended periods without cleaning of heat transfer equipment is desired, or where the corrosion potential of the circulating system is high. Usually, processing industries require the use of this approach.

Corrosion and Deposit Control. Corrosion could be practically stopped by operating at a high pH; but the pH required could result in the serious deposit of solids in high temperature heat transfer equipment. Also, the deposit of solids could be controlled by operating at a low pH, but such a pH level could result in serious corrosion and premature failure of equipment. Because of these problems, most treating methods operate at 6 to 7 pH where most salts are soluble and apply inhibitors to control corrosion. Some latitude in treating is gained by adding agents which hold insoluble salts in solution or suspension. Also, by controlling blowdown, insoluble salts may be held below their depositing concentration. This concentration is an individual system characteristic which can be calculated or based on heat transfer observations.

Inhibitors. Although the dividing line between corrosion inhibitors and deposition control agents for recirculating systems is not too fine, materials used primarily as corrosion inhibitors will be discussed first. Probably the most frequently used corrosion inhibitors are the chromates and polyphosphates. Other inhibitors less frequently used are silicates, nitrates, zinc salts, fluorides, ferricyanides, reduced chromate or chromous oxide, and various organic agents.

Corrosion inhibitors are usually classified as anodic or cathodic inhibitors, depending on the way they function to control corrosion. An anodic inhibitor functions by restraining the anode corrosion reaction:

$$Fe^{0} = Fe^{+2} + 2e$$

Such inhibitors usually function by reacting with corrosion products to form a protective film at the anode. (Chromates and nitrates are examples of anodic inhibitors.) Care must be taken in applying anodic inhibitors (by watching for increased pitting type corrosion) because of their tendency to increase pitting when applied in insufficient amounts.

Cathodic inhibitors are those which restrain the cathode corrosion reaction:

$$O_2 + 2\,H_2O + 4e = 4\,(OH)^{-1}$$

Generally, any material which forms a thin, uniform coating over metal surfaces to exclude oxygen acts as a cathodic inhibitor. (Polyphosphates, calcium carbonate scale, silicates, zinc salts, reduced chromate, fluorides under certain conditions, and organic filming agents are examples of cathodic inhibitors.) Cathodic inhibitors are often termed "safe" inhibitors in that corrosion is reduced uniformly and pitting is not stimulated. Since most act as coating agents, care must be taken in applying them to prevent deposition in heat transfer equipment (by watching closely for increased deposits).

Chromates. Of the many corrosion inhibiting agents, one of the most popular is the chromate group. These are widely used to control corrosion in closed systems, for example, automobile radiators. In recirculating systems, however, the application is usually in conjunction with other inhibitors, such as polyphosphates and/or zinc. Used alone, chromates, being anodic inhibitors, require very high residuals to effect protection against pitting attack. Further, maximum effectiveness is obtained at a pH level where, with a reasonable blowdown rate, scaling becomes a problem. These two factors combined would result in a prohibitively expensive treatment in a recirculating system. Neither of these factors would materially affect treating cost in a closed system. However, chromates, when applied at low residuals with other inhibitors, function to markedly improve film-forming abilities of the other inhibitors.[2] The reason for this action is thought by many authorities to be a result of their strong oxidizing properties.[3] Many inhibitors form their most dense protective films by reaction with corrosion by-products at their highest valency, i.e. ferric and cupric ion. Chromate, even at low residuals, effects this desired oxidation without undesirable by-products and, at the same time, affords some protection to such metals as copper-zinc alloys.

Nitrites are seldom used in recirculating systems because of their inability to control corrosion on copper and copper alloys. In open systems, it is difficult to control microbiological growths in the presence of nitrites because they stimulate such growths. They are not effective corrosion inhibitors at the acid pH level usually required to control deposition in recirculating systems. However, nitrites are sometimes used in closed systems where these drawbacks are not present.[4]

Polyphosphates are probably the inhibitors most widely used in recirculating systems. They not only control corrosion but control deposition and remove previously formed scale and tuberculation as well. For a number of years, polyphosphates were thought to work as anodic inhibitors. However, more recent information has indicated that they function as cathodic inhibitors.[5] Corrosion control in cold water systems, such as in city water distribution, is obtained with as little as 2 ppm dosage. Recirculating systems, however, require 10 ppm and above to control corrosion. Such residuals will provide good corrosion protection to a number of metals, particularly those of ferrous nature. Polyphosphates are made by molecularly dehydrating ortho phosphates at high temperatures. Unfortunately, this dehydrating action is reversible to the extent that a sizeable portion of the polyphosphate applied to a recirculating system reverts to the ortho form. In the poly form, phosphates react with nearly all salts to form soluble complexes while in the ortho form they react to form highly insoluble sludges. This action sets a limit on the residuals which can be carried in a recirculating system without encountering a scaling problem. Usually, this limit is below that required to afford protection to all of the metals in a system. Copper alloys, in particular, require higher residuals than this limit. As a result, satisfactory application of phosphates to recirculating systems usually requires the use of supplementary inhibitors such as chromates and/or zinc.

Zinc polyphosphates are sometimes used in lieu of straight polyphosphates for corrosion protection in recirculating systems.[6] The zinc serves as a cathodic inhibitor in the form of zinc ortho phosphate to extend the corrosion protection afforded by polyphosphates.

The ortho phosphate results from reversion of the polyphosphate. The zinc also materially improves the protection afforded copper alloys. By utilizing zinc polyphosphates, protection can be obtained at a low enough polyphosphate level to somewhat overcome the deposition problem, as noted above. Zinc functions as a coating agent, however, and deposition can be increased if proper controls are not utilized. Where large quantities of materials (over three ppm) are present, such as aluminum and iron, which react with polyphosphates, better results can be obtained by applying zinc and polyphosphates separately. Zinc salts, being coating agents, require close control to prevent excessive deposition. Phosphates can also increase deposition. With separate addition, an optimum control can be obtained.

Fluorides are frequently applied to recirculating systems where the makeup water is high in aluminum salts (over 0.5 ppm). They are used mainly as sequestering agents to control deposits of these salts, but corrosion control is also obtained provided aluminum salts and small amounts of polyphosphates are present in the recirculating water. Their functioning is similar to polyphosphates; though efficiency as corrosion inhibitors is somewhat less. Application is usually to systems where polyphosphate type action is desired but cannot be obtained because of the presence of aluminum. The range of fluoride injection is usually two to four ppm, as F, for each ppm of aluminum, as Al.

Ferricyanides are used as corrosion inhibitors along with the polyphosphates and are added in a range of one to three ppm as $Na_3Fe(CN)_6$. They function on the stain principle and serve to increase the film-forming ability of polyphosphates. In systems with both copper alloys and steel, the complexing or chelating ability of ferricyanides ties up the copper ion preventing its deposition on steel with the increased pitting which results.

Reduced chromate or chromous oxide (six to nine ppm as CrO_4) is used in systems where the presence of reducing agents in the recirculating water makes the development of a chromate residual, at all times, impossible. The presence of reducing agents is usually caused by either leakage of process materials into the recirculating water or atmospheric conditions. Reduced chromate is a great deal less effective as a corrosion inhibitor than unreduced chromate; as a result, other inhibitors, particularly polyphosphate, are applied with them in a range of seven to 10 ppm, as PO_4. They act as a cathodic inhibitor operating on the coating principle. Coating density is controlled by means of residuals carried and dispersing material concentration. In most applications, polyphosphates serve as the dispersant. Reduced chromate functions best when chromate is fed unreduced and reduction is insitu.

Organic Inhibitors. A number of organic agents have been applied to recirculating systems, but most of these are for deposition rather than corrosion control. Although a great deal of work has been, or is being done, on development of such materials, there are not many successful applications at the present time. One of the main difficulties is finding a material which will compete cost-wise and performance-wise with the inorganic agents already in use. The only well known application of organic agents for corrosion control in recirculating systems is 2-benzothiozolethiol along with zinc and polyphosphate. This agent specifically protects copper alloys and thus allows operating the polyphosphate treatment at an optimum point.[7]

Control of Scale Deposits. In general, deposition control is more difficult than corrosion control. In some instances, deposition control can be obtained by operating at a pH level where only the most insoluble salts will deposit and controlling the level of insoluble salts by blowdown. For systems cooling process units, however, this type of control usually has to be supplemented by agents which will broaden the solubility limits of insoluble salts.

Materials which will control deposition can be generally classified as: (1) dispersing agents, (2) stabilizing agents, and (3) sequestering agents. Dispersing agents are those which permit precipitation of scale-forming salts but prevent their agglomeration into scale on heat transfer surfaces. Detergents fall into this classification. Stabilizing agents are those which inhibit the precipitation of scale-forming salts, thus permitting operating at an over-saturated state. Polyphosphates, tannins, lignins, starches, and various combinations of these materials fall into this classification. Sequestering agents are those which react with a scale-forming salt to form a complex ion appreciably more soluble than the original salt. Polyphosphates, fluorides, versenates, and various organic materials fall into this category. For most deposition problems, application of dispersing and stabilizing agents, or a combination of the two, is adequate. For more difficult problems, the application of sequestering agents is required. Generally, the use of dispersing and stabilizing agents is much less expensive than use of sequestering agents. Dispersing and stabilizing agents can usually accomplish good results with as little as one to five ppm residual in the circulating water, where sequestering agents require from two to 10 ppm for each ppm of offending salt.

Many recirculating systems use a surface water makeup which has been only coagulated and settled to remove turbidity. Where these surface waters prove difficult to coagulate and aluminum salts are used as coagulants, the salts are introduced into the recirculating systems both in the soluble and suspended form. Controlling deposition of these salts frequently proves to be a particularly troublesome problem. Solubility of aluminum is approximately 0.1 ppm, in the 6.0 to 7.5 pH band used in treating recirculating water. It is not uncommon for waters to contain 1 ppm of aluminum salts. Thus, at reasonable cycles of concentration, such as five to one, the aluminum content can be 50 times higher than its solubility limit. Dispersing agents are not too effective in preventing deposition at these levels above the solubility limits because of the agglomerating effect of high temperatures in heat transfer equipment. Known stabilizing agents do not function too well for the same reason. Sequestering or chelating aluminum is also difficult, as most organic chelating agents break down at temperature levels effective in heat transfer equipment. Polyphosphates will to some extent sequester aluminum, requiring six to 12 ppm polyphosphates per ppm of aluminum. Polyphosphates in this case have a strong drawback; for, if a sufficient quantity to control aluminum is applied, the by-product, ortho phosphate, will result in deposition of calcium and other phosphate salts.

For this reason, polyphosphates are not suitable answers to the problem.

Recently, the application of fluoride ion to control aluminum deposition has been made. Fluoride reacts with aluminum salts, particularly those that are soluble, to form a soluble complex which is stable at temperature levels in a circulating system. Approximately two to four ppm of fluoride are required per ppm of aluminum. Further, the complex formed has corrosion inhibiting properties, functioning similarly to polyphosphate. At the present time, the fluoride approach to controlling aluminum deposition in circulating systems is the least expensive and the most satisfactory available.

Biological Fouling. Another source of deposition and, to a lesser extent, corrosion, is microbiological growths, such as algae and slime. Slime, in particular, can be troublesome because of its ability to grow in heat transfer equipment. These growths are controlled by adding growth killing poisons to the system. Examples of such materials are chlorine, chlorophenols, pentachlorophenates, copper salts, quaternary amines, and 2-benzothiozolethiol. Of these, chlorine is the most widely used because it can kill a wide variety of growths at low cost.

The growths will develop an immunity to any one poison if exposed to it continuously over a period of time. As a result, application on a "shock" basis or alternating basis with another poison is required. For effective kills, dosages vary from one to two ppm for chlorine to 200 ppm for pentachlorophenates.

Of the materials used, chlorine and copper salts can increase corrosion. Chlorine increases corrosion by virtue of its oxidizing properties; copper salts increase pitting corrosion by plating out on ferrous surfaces. Copper salts are, as a result, not frequently applied to circulating systems. Chlorine corrosion is controlled by limiting free chlorine residuals to two ppm and applying it "shockwise."

Any system of treatment for recirculating tower systems must take into account the effect on the wood in the cooling tower, as well as metals in the system. Failure of the cooling tower could result in crippling a process more severely than failure of lines and heat transfer equipment. Generally, protection of tower wood requires that high alkalinites and high residuals of strong oxidizing agents, such as chlorine, be avoided.[8] Fortunately, most modern treatments for controlling deposition and corrosion in process equipment have the same requirements. One exception is chlorine application where continuous residuals in the order of 0.5 ppm free chlorine will not appreciably increase corrosion but can result in serious attack of the tower wood.

Treating Efficiency. Treating of recirculating water for processing units is complex because of various metals and alloys used, the wide range of temperatures, and the widely different velocities used in heat transfer equipment. No one inhibitor will give adequate protection under these conditions. Thus, a combination of inhibitors and agents is required.

A processing unit in the design stages should be carefully checked for future sources of trouble. Consider carefully such points as the use of metals which cannot be effectively protected, the coupling of widely dissimilar metals, excessively low or high velocities in heat transfer equipment, high design outlet temperatures on coolers and excessively high heat rejection temperatures to cooling water. After a system is in operation, continuous study should be given to processing conditions and other factors affecting performance of the water treatment. Consideration should be given to such points as outlet temperatures from process coolers, treating chemical residual control, pH control, blowdown control, makeup water quality, microbiological growth control, and the relative corrosion level. The corrosion level can be obtained by exposure of metal coupons in suitable manifolds and subjecting these coupons to periodic examination. Heat transfer equipment on processing units should be inspected at every opportunity to ascertain the effectiveness of the water treatment.

Where treatments from outside firms are applied, it is important to have a good understanding with their representatives, so that treatments can be modified as required to meet changing conditions. Where treatments are made by the operating company, laboratory and pilot plant work toward treatment improvement is usually needed. The complexity of water treating in recirculating cooling tower systems servicing processing units generally will result in change and modification being the rule, rather than the exception.

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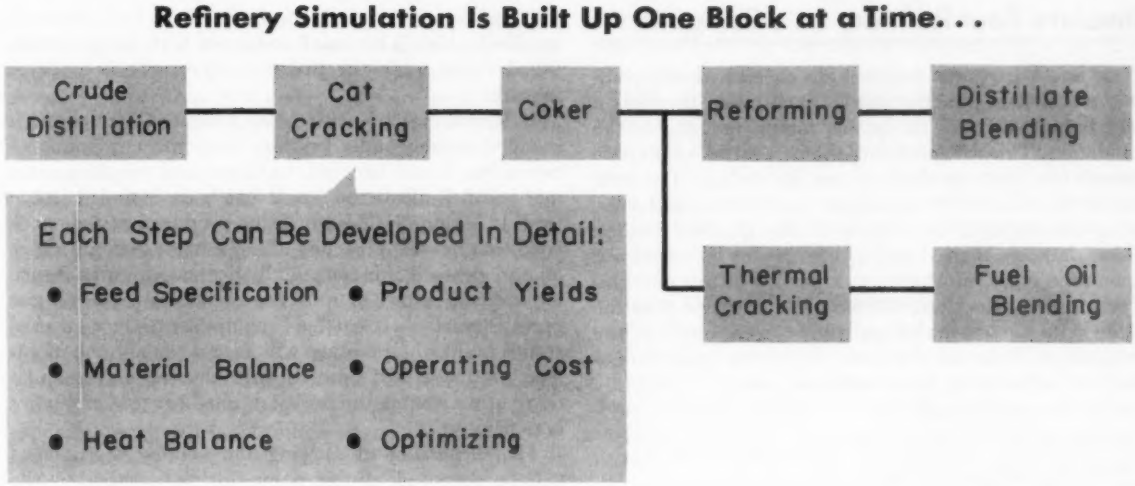
About the Author

Ralph P. Gulley is an engineering specialist at Gulf Oil Corp.'s Port Arthur, Texas, refinery where he is in charge of process corrosion control and chemical cleaning. Holder of a B.S. degree in chemical engineering from Louisiana State University, his experience since graduation has been with Gulf. He has worked in the fields of general utilities, pollution control, water treating, cooling tower testing and inspection, corrosion control and chemical cleaning.



Simulate Your Refinery on a Computer

Here are some of the points considered by one refiner in setting up a refinery simulation program. See how the computer program can make it easier for you to calculate the best product distribution under varying conditions

R. C. Shea, Cities Service Oil Company
Bartlesville, Okla.

REFINERY SIMULATION is a familiar word, but does it have the same connotation to everyone? Even though the fundamental models in several cases may be similar, each one can present a refiner with specific problems to analyze that may be unimportant or even nonexistent to another refiner. Therefore, it would be well to define what we mean by the fundamental model and then give a detailed discussion of a simulation program.

As the name might imply, the basic purpose of a refinery simulation is to duplicate as nearly as possible the physical operations of the plant. It must contain the flexibility to calculate a product distribution under varying conditions of feed, operating variables, product requirements and the removal or addition of processing equipment; anything less than this could not be considered a simulation. It is highly desirable to include the logic and ability to optimize unit and total plant operations, including the selection of the crude slate, however, these are refinements that may have to be excluded in specific cases because of limited computer memory.

So much for the definition. The following summary of the calculation sequence in the simulation will serve to indicate in a general way the scope, flexibility and logic which is available in the program. The refinery for which this model was made is a 30,000 barrel a day plant with the following process units:

- Atmospheric and vacuum crude distillation
- Catalytic cracking
- Catalytic reforming
- Coking and thermal cracking
- Reforming units.

The computing equipment that processes the simulation program is of medium size with indexing registers, automatic floating point and is equipped with an alphabetic print-out device.

Since a refinery is a group of separate units, each having its own function, we built the simulation one unit or one block at a time. These blocks were in effect, unit simulations, and when all were completed it was a fairly simple matter to tie them together to form the completed refinery simulation. There were two good reasons for this approach. First, as each unit simulation was completed we had a tool available that could be used to study specific operating parameters for improved efficiencies on that unit. Second, the construction of the refinery simulation in blocks facilitated the later addition and removal of units for studying the effect of equipment changes.

Start With Crude Analyses. Since we must describe to the program the quantity and quality of crude oil to be processed, the basic input data are what we call the crude decks. The source of these data is a laboratory

crude assay. Pertinent information on each crude available is stored in punched cards. Each crude then has a deck that contains all the quality factors required by the simulation. Thus by specifying the percent of each crude desired any given crude slate can be studied. The next step is to calculate the composite crude by weight-averaging the required qualities of the specified crudes. These data are then stored in memory to be called out when required. Unfortunately, a portion of this program is erased at a later date, therefore, we may not alter the crude slate automatically and thus cannot optimize the crude slate. Some of the more important quality data that are included in the crude decks are:

- True boiling distillation
- Gravity-mid percent
- Virgin gasoline octane
- Virgin gasoline vapor pressure
- PONA analysis of front end
- Light ends analysis
- Carbon residue
- Crude cost.

These data are stored as tables, equations of curves or as simple average values as the case may be.

With the composite crude established, crude unit yields and gravities are calculated. These yields are determined by a series of pre-established cut points. However, the yields can be automatically varied at subsequent points in the program; hence, the pre-established temperatures serve only as "starting points."

The use of these yields and data in subsequent blocks will require certain quality factors be known. For instance, before we may calculate yields at the catalytic cracker, we must know what kind of feed we have; and certainly we must know the octane and vapor pressure of the gasoline before we can blend to finished specifications. Therefore, the qualities required for each stream are determined. Of course these qualities may be changed just as the yields may be varied.

Examine Cat Cracking in Detail. The next block in our program is the catalytic cracker. The first part of the block we call the feed preparation routine. By this we do not mean desulfurization, hydrogenation or such; but rather the establishment of the volume of feed. This small section illustrates very well some of the minor logic built into the simulation which provides flexibility in its use. Cracking feed may be established in either of two ways. First a given feed volume may be specified. Second, if a fixed volume is not specified it will be determined by the pre-established crude unit cut points; providing that volume does not exceed the maximum feed limitation of the unit.

If either maximum feed or specified feed is exceeded, adjustment is made in the following manner. The production of Virgin No. 2 fuel is increased incrementally until the volume of cat feed has been reduced sufficiently or until some specification of No. 2 fuel is exceeded. If the No. 2 fuel limitation is reached and cat feed is still excessive, the cat feed end point is reduced incrementally—or resid production is increased—until the cat feed requirement has been met.

If, on the other hand, a volume of cat feed has been specified which is too small consistent with the pre-established crude unit cut points, adjustment is made as follows:

If Virgin No. 2 Fuel is being produced, its volume is reduced incrementally by decreasing the cut point between No. 2 and cat feed, until cat feed requirement is met or until all of the No. 2 has been included in cat feed. If Virgin No. 2 is not being produced or the above condition has been reached, the cut point between range oil and cat feed is incrementally decreased until cat feed requirement is met or until the minimum range oil end point is reached. If cat feed requirement is not satisfied at this point, the program will accept the volume of cat feed produced and proceed with the cat unit calculations, as we assume the pre-established cat feed end point is maximum.

The mechanics of altering the volume of cat feed will be discussed at this point, for the method is the same when any virgin product volume is altered. Each time the boiling range of a product is changed, the volume not only changes but also the quality. For this reason, after changing the appropriate cut point the program sequence control is returned to the crude unit and all calculations repeated. The incremental change in cut point is small, usually one degree, which allows convergance on the necessary volume within a very few barrels.

There are better and quicker methods of converging on a volume and of adjusting product qualities, but one thing that had to be kept in mind throughout the development of this simulation was the limitation of computer memory. Therefore, we had to maintain a balance between computing speed and memory requirements. By writing the program such that it was resetting, we could converge on a desired or required volume by the iterative method while the use of a shorter method such as Twenty Questions would have required additional memory.

Cat feed quantity and quality having been established, we are now ready to determine the cat cracker operation. There are four steps involved in these calculations. We first make a feed-recycle-carbon material balance; second, we calculate the reactor-regenerator heat balance; next we determine the product yields and finally the unit operating expenses are compiled.

Of the four steps, we need discuss only the prediction of product yields and calculation of expenses, for the material and heat balances are quite straight-forward calculations giving results such as reactor temperature, catalyst to oil ratio, space velocity, severity, etc.

The prediction of product yields is accomplished by the use of a series of equations which were developed by regression analysis of actual unit operating data. These equations relate pertinent operating conditions to the yield of the various products, thus reflecting the expected product distribution for any given set of operating conditions.

Master card files containing daily observations of all unit operating conditions provided the data for the regression analysis. These are raw data as logged at the unit, and therefore contain errors due to meter drift, gaging errors and so on. To minimize this error and improve the reliability of our equations, we placed quite severe requirements on the data selected for use in the

regression analysis. First, we rejected data for any day that contained an unqualified zero (any missing observation). Second, only those days that had a weight recovery of between 99.6 and 100.4 were used. The resulting equations gave a reliability or a 99.5 percent confidence limit of plus or minus 1 to 1.25 percent which we considered acceptable.

The calculation of unit expenses is broken down into fixed and variable categories. Fixed expenses include unit operating labor, maintenance labor, maintenance materials, retirement, thrift and group insurance. Variable expenses are comprised of operating supplies, electricity, fuel, chemicals, catalyst, royalty and steam. Cooling water expense is broken down as follows: pumping expense is included in electricity; makeup water is included in operating supplies and treating expense is included in chemical costs. The variable expenses are calculated as a function of feed rate, product yield or some other operating variable such as combined feed temperature and feed gravity in the case of fuel expense. Before proceeding to the next block, each of the individual expenses are added in with the total plant expense and the products are distributed either to a finished product pool, such as the gas, or to a subsequent unit or blending pool such as the gasoline streams. Of course, quality factors like octane, vapor pressure and lead susceptibility are transferred at the same time.

Cat cracker operating conditions may be optimized at this point in the program, if it is desired. Any one or all of the following variables may be adjusted to obtain the optimum:

- Thruput ratio
- Gasoline, naphtha and light gas oil end points
- Combined feed temperature.

The criterion for optimization may be either conversion or a pseudo product value. The mechanics of determining the optimum is the method of steepest ascents whereby the partial derivatives of the response (either conversion or product value) with respect to each of the variables, are calculated. These values are used as a guide for further incremental changes in the variables until no further increase in the response is obtained or until the variables have reached their maximum or minimum values.

When this condition has been reached, we have the combination of variables that will produce the most desirable result within the limitations placed on the calculation. The calculate time required to converge on the optimum of course depends on how "good" a first choice was made for each of the variables. Each of these are input data, therefore, if the input value is close to the optimum, very little time is required. An average length of time would be about three minutes.

In order to calculate the heat balance, material balance and product yields, we require certain input data. These include the air rate, thruput ratio, combined feed temperature, stripping steam quantity and product cut points. Some of these values may be changed automatically within the program for one of two reasons. First, they may be changed if, and when the unit operation is optimized as discussed previously; second, they may be changed because of heat balance requirements. To illustrate the latter; the coke burning capacity, set by the input data, is used, providing it does not cause some other variable to exceed a minimum or maximum value. We might have set the air rate so high that to maintain heat balance, the reactor temperature would have to exceed the maximum allowable by the reactor vessel. In such an event, the program would increase the thruput ratio to its maximum value and then decrease the air rate until the reactor temperature is reduced to the maximum value. Similar checks on vessel capacities and operating variables are made throughout the simulation so that when we calculate any plant operation we can expect it to be realistic.

Handle Other Units Similarly. The next five blocks in the simulation involve the operation of a coker, thermal cracking and reforming units, distillate blending and heavy fuel oil blending. Yield calculations on these units are quite similar in that the yields are based entirely on the type of feed being processed. The approach to the development of these units was the same as for the cat cracker, that is the yield predictions, expense calculations and product distribution, therefore no further discussion is needed on the subject.

One point of interest is the fact that any one or combination of units can be shut down with automatic disposition of the feed. This is accomplished by having a control word containing eights and/or nines and using the branch on distributor logic to determine whether any given unit is to operate. An economic evaluation of the operation of the coker and the thermal units as to whether they should be operated cannot be done automatically within the simulation but must be done by a case study method. In other words, these units cannot be shut down by the program.

Consider Fuel Oil Blending. Intermingled with the actual yield and blending calculations is the logic which governs the order of disposition of vacuum tar, heavy cat cycle oil and range oil, the unit feeds mentioned above. This is best viewed as a whole, removed from the sequence in which it actually occurs.

The first priority on vacuum tar is for feed to the coker if it is operating. Heavy cat cycle oil is also used as feed to blend "down" the tar viscosity, therefore the necessary volume of this material is added to the coker feed. If a sale exists for straight tar, that volume, indicated by the input data, has second priority and is stored as a finished product. The remaining tar, if any, is disposed of by blending the maximum amount possible to No. 6 fuel and burning the excess as plant fuel.

The disposition of heavy cat cycle oil is similar to that of tar. As mentioned previously, a small amount is used as coker feed and this volume is set aside first. If the thermal unit is operating, the remaining volume is charged to that unit. If not, or if the remaining volume exceeds the thermal unit capacity, the excess is disposed of either as a "black" oil sale if such a sale exists, or as plant fuel.

The disposition of range oil is as follows: The volume required for No. 2 fuel blending is set aside first. Then up to a specified volume is sold as range oil. If operating, spare capacity on the thermal unit is filled by cracking the range oil. If the thermal unit is not operating, or if it is not desired to crack range oil, or if the capacity of the unit has been filled, any balance will be downgraded to No. 2 fuel.

The portions of the streams discussed above which

have been earmarked for fuel blending, along with the remaining fuel oil blending stocks, are then combined into finished products in the following manner: Cat light cycle oil, coker No. 2 fuel and No. 2 from the thermal operations are combined to form a cracked No. 2 fuel base pool. The minimum range oil required for the pool to meet No. 2 fuel product specifications is added. If virgin No. 2 fuel has been produced it is blended with enough range oil to meet specification. The cracked No. 2 fuel plus the virgin No. 2 fuel along with any range oil that had to be downgraded then represents the total plant production of No. 2 fuel oil.

The heavy fuel oil blending procedure is similar to the light oil blends and results in the volume of No. 6 fuel produced, heavy oils to be sold and liquid fuel available for plant fuel.

Set Reforming to Suit Gasoline Need. There now remains one unit operation to determine and that is the catalytic reformer. It is closely allied with the gasoline blending calculations in that the reformer is generally operated to balance gasoline octane requirements for each pass through and within the simulation. Therefore, these two blocks will be discussed as one.

Reformer feed volume is established initially by the pre-determined crude unit cut points, and generally represents the minimum volume that can reasonably be produced. This volume may be increased in subsequent loops by lowering the initial boiling point. Protection against overloading the unit is obtained by specifying a minimum initial boiling point *and* a maximum feed rate. Further increases in feed are stopped when one of these limits is reached. The end point of the feed cannot be changed automatically by the simulation program.

Product yields are calculated as a function of feed rate and quality plus operating conditions. Again, as for the other units, expense calculations and a product distribution is made, and then the program enters the gasoline blend section.

Gasoline streams are blended in a pool using blending values or blending octanes at a specified tetraethyl lead level. The pool can be blended to one of the following conditions which must be specified, along with regular and premium octanes and vapor pressure requirements.

- A given volume of premium gasoline
- A given volume of premium *and* regular
- A given percent premium
- Maximum total gasoline where pool octane can fall anywhere between regular and premium levels
- Same as the latter except that premium volume must not exceed a specified amount.

The simulation program was written so that maximum total gasoline volume is automatically produced in all cases. To accomplish this, and it is a necessary requirement to fit the logic of the program, reformer feed rate and severity must be at the minimum value and lead level at its maximum value. Any adjustments then necessary to meet gasoline requirements need be made in only one direction.

To meet the requirements for gasoline just discussed, or to balance octane requirements, adjustments are made in the following order. If more octanes are required, catalytic reformer feed volume is increased by increments until it is maximum. This is accomplished by lowering the initial boiling point one degree and returning to the crude unit. If sufficient octanes are still not available, the feed volume is decreased to its original level, reformer severity is increased one point and the procedure just described is repeated. If these two loops have reached their maximum limits without providing sufficient pool octane, natural gasoline volume (which is used as a pressurizing material) is reduced incrementally to zero. If octane requirements are not satisfied at this point, the program stops and indicates the gasoline requirements specified by the input data is impossible to make. If less octane is required, pool lead level is decreased.

Provision was made to evaluate additional gasoline streams in the pool. This flexibility provides for study of purchased blending stocks, installation of additional process units, use of fixed volumes of natural gasoline or butane, etc. If use of an additional stream is desired, its blending octane unleaded, lead susceptibility, vapor pressure, volume and price, if applicable, must be specified in the input data.

Figure In Cost. The final step in the simulation is the evaluation of the operation. The economic calculations include the determination of revenue from finished products and the summarization of manufacturing expenses. The desired schedule of product prices is included as variable input data. Any price, including zero, may be used. Since natural gasoline is purchased in variable costs increments due to freight, the final cost of this material used reflects the volume used. This is accomplished with a cost table with space for a number of increments. Each increment includes volume along with a price for which that volume can be laid into the plant. Since the program uses the table in sequence, the table reflects the manner in which the natural gasoline must be purchased; therefore, the prices are not necessarily in dollar value sequence. Following the determination of revenue and expenses, the crude cost is calculated, and the final plant margin is computed. ##

About the Author

Richard C. Shea is responsible for computer application and analysis of process engineering studies for Cities Service Oil Company in Bartlesville. Having received a B.S. degree in petroleum refining engineering from the University of Tulsa in 1950, he joined Cities Service's Ponca City refinery. There he spent one year in the Engineering-Maintenance Department, one year as operating shift foreman, and two years in the Process Engineering Department. He then transferred to the Bartlesville office where he organized and until recently directed the division's computer group.

PART 20

Automation Today

Here is a more exact graphical method to supplement the rough sketch of a system's response. The response plot is accurate enough now to show you what control system to use.

Theodore J. Williams and Verlin A. Lauher
Monsanto Chemical Company, St. Louis

IN THE PRECEDING part of this series, we developed several rules of procedure which were necessary to follow in order to sketch a root locus plot. On the basis of these rules, an approximate picture of the root loci for a given function can be obtained without an extensive mathematical analysis. After carrying out the sketching of a few such examples, the analyst will acquire the ability to picture intuitively the shape of the loci for a large variety of pole-zero combinations.

In many cases, however, a rough sketch will not be adequate if a control system design is the end product desired. Refinements in this rough sketch may be obtained by either a graphical or an analytical approach, although the graphical approach is certainly much easier. This article will aid the analyst in developing the exact graphical methods needed to obtain a very accurate plot of the loci of the roots of a function.

GRAPHICAL CONSTRUCTION OF THE ROOT LOCUS

First the root locus is sketched using the rules developed in Part 19. The reader is referred to this previous part for a review of the rules (PETROLEUM REFINER, March, 1960, Page 170).

The basis for the graphic method of plotting is expressed by the following statement. The sum of the angles to any point in the plane must add up to 180°.

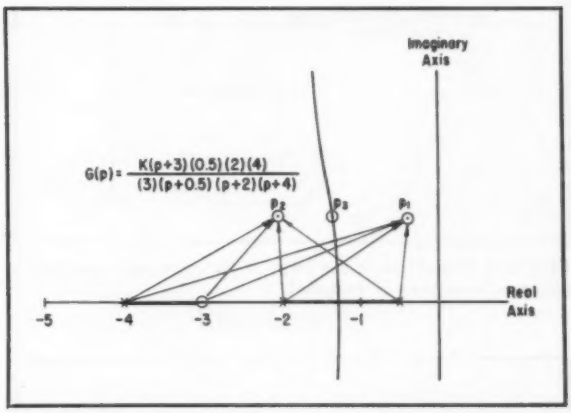


FIGURE 132—The root locus is drawn through the points which satisfy the requirement that the sum of their angles equals to 180°.

More precisely, *the sum of the angles made by the vectors from the open loop zeroes to the point in question (say p_1) minus the sum of the angles made by the vectors from the open loop poles to the same point (p_1) must equal 180°.* In equation form, this becomes:

$$\Sigma\ (\angle \text{ vectors from open loop zeroes to } p_1) - \Sigma\ (\angle \text{ vectors from open loop poles to } p_1) = 180 \pm n(360)$$

Where n is any integer. All methods of construction must rely on this basic equation. The method can readily be carried out through the use of a protractor and a trial and error procedure to locate and try successive points until the equation is satisfied.

An Example. Consider the example,

$$G(p) = \frac{K\ (p+3)\ (0.5)\ (2)\ (4)}{(3)\ (p+0.5)\ (p+2)\ (p+4)}$$

and locate the open loop poles on a plot as shown in Figure 132. Pick the point p_1 and measure the angles to that point. Taking the first angle as the one on the

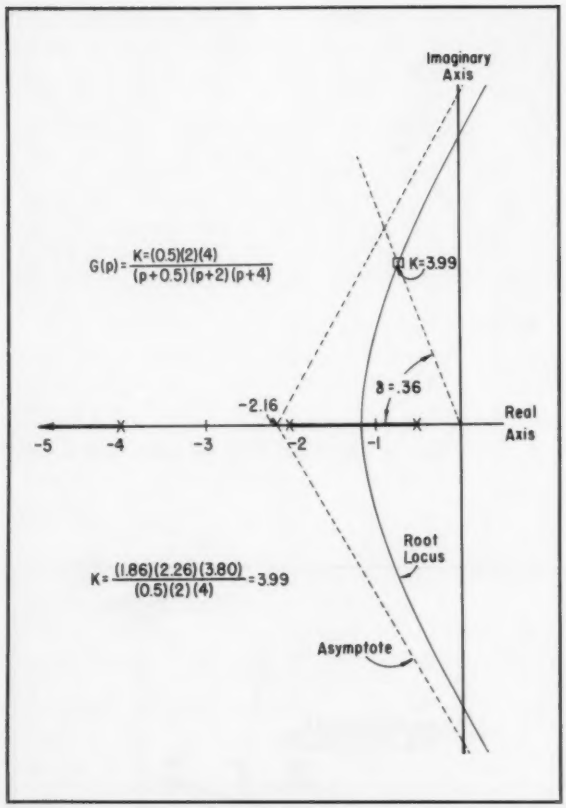


FIGURE 133—Here is the form of the root locus plot when no open loop zero is included.

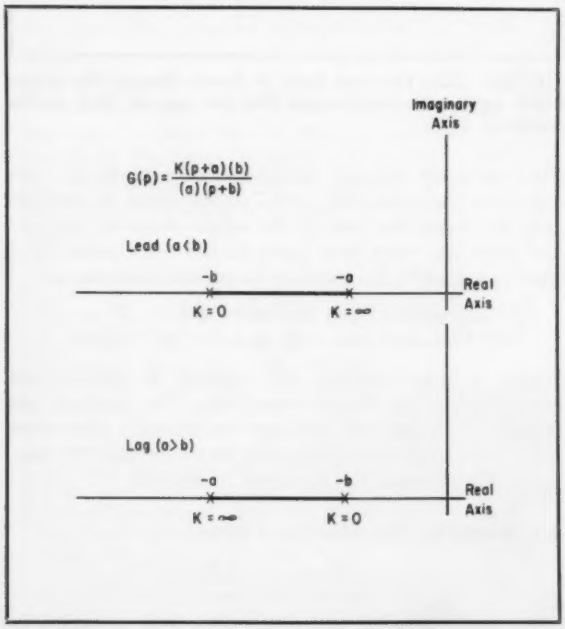


FIGURE 134—A root locus plot of a lead compensation (derivative control) is shown in the upper portion, and lag compensation (integral control) is shown in the lower portion.

far left and proceeding to the right, the resulting total becomes $16° - 21° + 33 + 85 = 113°$, *not* 180°.

Logically, we should next try a point p_2 which is to the left of the previous point, p_1. Point p_2 yields $30° - 49° + 92° + 144° = 217°$. Point p_3 (between the other two) gives a sum of angles equal to $23° - 34° + 61° + 130° = 180°$ and is thus a point on the root locus.

Various other points must also be located on the plot in the same manner. The root locus may then be drawn through those points which satisfied the requirement that the sum of their angles added up to 180°. This locus of points is shown as a line in Figure 132. Notice that the zero has the effect of "pulling" the locus towards itself. In fact, the open loop poles may themselves be considered as "mountains" and the open loop zeroes as "valleys" to the closed loop root locus.

We will remember that all loci begin at poles (top of the mountain) and terminate at zeroes (valleys) as the over-all system gain, K, varies from zero to infinity. If one plot the locus of $G(p) = \frac{K(0.5)\ (2)\ (4)}{(p+0.5)\ (p+2)\ (p+4)}$ (i.e., deleting the zero), the results are shown in Figure 133.

The effect of the zero now becomes very apparent where Figure 132 is compared to Figure 133. It would, therefore, seem the addition of a zero would aid in producing a more controllable system. This is indeed true for this particular case, but may not necessarily be true for all other examples. What was actually accomplished here was the addition of a pure "lead compensation" (derivative control) to the system by the addition of the zero to $G(p)$.

In practice, the addition of a pure lead term is very difficult. Usually a lead compensation of the form $G(p) = \frac{p+a}{p+b}$ (where $a < b$) must be used because it is the only one physically realizable. A root locus plot of such a lead compensation is shown in the upper portion of Figure 134. If $a > b$, then a lag compensation (integral control) is obtained. The root locus plot of the lag compensator or integrator is shown in the lower portion of Figure 134.

Combining the use of the rules and the exact graphical methods accomplishes two things. One, the simple rules for construction of the root locus allow one to make a quick sketch of the general form of the locus. Two, the graphical addition of angles allows accurate plots in the regions of special interest; the use of the term $\delta = .36$ and the point of crossing of the imaginary axis are two prime examples of this. The use of a desk calculator and a table of tangents will allow one to carry out the computations to any accuracy necessary for any engineering study.

Mechanical graphic aids are also available to assist

the analysts in the quick plotting of the root locus. One device consists of a transparent protractor for addition of the angles directly and a logarithmic spiral for multiplication of vector lengths to determine the resulting gain.

THE EFFECT OF LOCATION OF A LAG COMPENSATOR

The reader should know how to locate the pole and zero of a lag compensator so that it will do the most good in improving system operation.

In a later part we will discuss the physical details of just how this adjustment of the compensator is accomplished in actual practice. At present we are only considering the effect of such changes and not how this positioning is physically performed.

First, we will incorporate a very fast (ω is a large value) device. The example we plan to study is $G(p) = \frac{K\,(0.5)\,(2)\,(4)}{(p+0.5)\,(p+2)\,(p+4)}$ (i.e., the same as shown in Figure 133). If we now add the lag term at high frequencies the resulting root locus is shown as Figure 135.

Notice that the K which corresponds on the locus to a $\delta = 0.36$ ($\alpha = 69°$) is indicated. Thus, we will have a comparison between the allowable gain for different locations of the lag network. A triangle is used to indicate which pole and zero represent the compensator or controller. Figure 136 shows the changes in the plot as the pole and zero of the controller are moved successively toward the origin. From this set of plots we see that the right hand case in Figure 136 shows the best improvement in response of the system (i.e., K is highest). The question now arises, what should be done to allow a quick determination of the optimum position (the one chosen may not be it). A graphical method of determining this correct value involves a modification of the root locus method which is called the Phase-Angle Loci plot.

PHASE-ANGLE LOCI

The phase angle loci plot shown in the first section of Figure 137 is for a single pole (i.e., $G(p) = \frac{K\,(a)}{p+a}$). The phase angle loci for a single zero are the same except that the sign of the angles is reversed.

The next case considered is that for a double pole which is derived from the relation:

$$\angle\, G(p) = \angle\, \frac{1}{p+a} + \angle\, \frac{1}{p+b}$$

The exact shape of the resulting loci depends upon the separation of the two pole. Figure 137 also shows the plot for one such separation. Notice the 180° phase angle loci is the root locus. The loci of a lead pole-zero combination is the last plot shown in Figure 137. The phase angle loci for a lag is the same except the sign of the angles is reversed. It can be seen that the com-

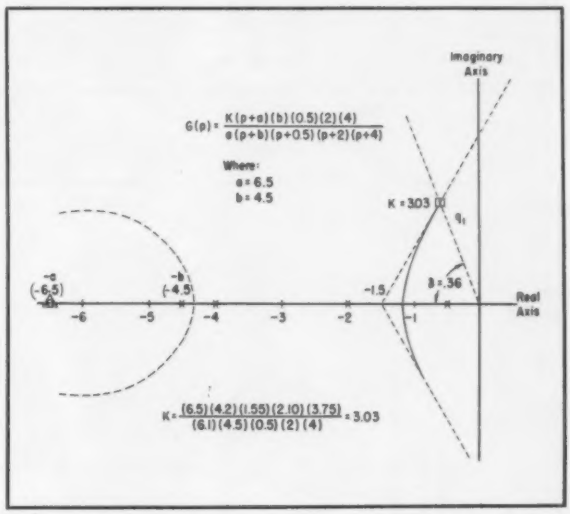


FIGURE 135—You should know how to position the pole and zero of a lag compensator. In this figure, the controller pole is —4.5 and the zero is —6.5.

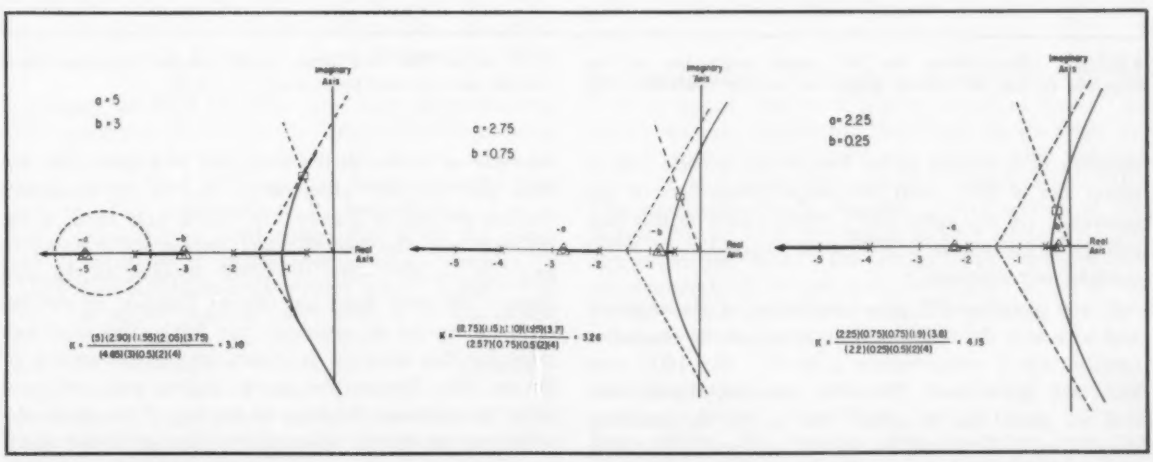


FIGURE 136—Gain (K) improves as the pole and zero of the controller (enclosed by small triangles) are moved successively toward the origin of a root locus plot. The equation for G(p) is the same as in Figure 135.

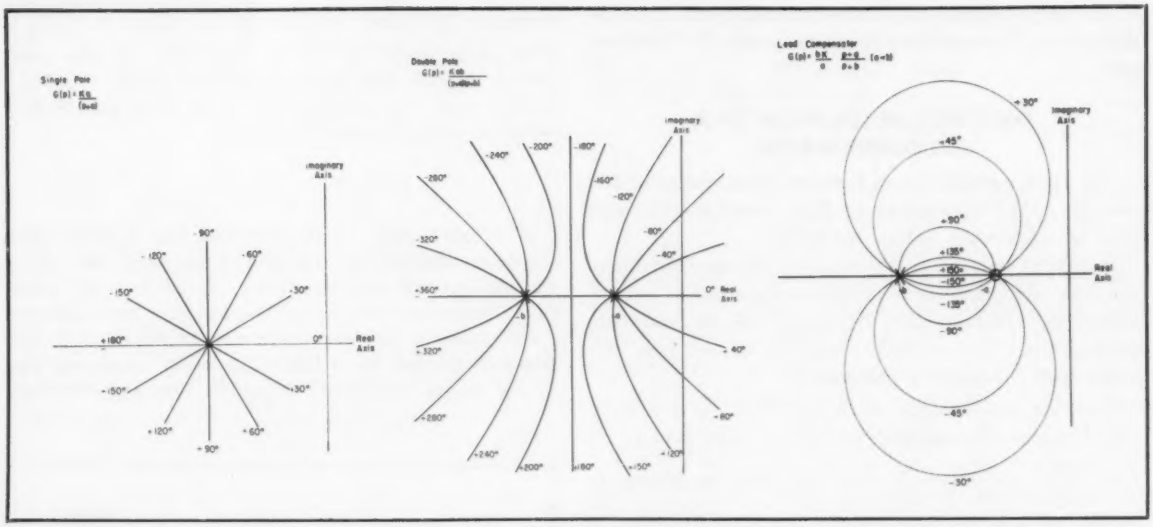


FIGURE 137—Phase angle loci for lag compensator is same as for lag compensator shown except sign of angles is reversed.

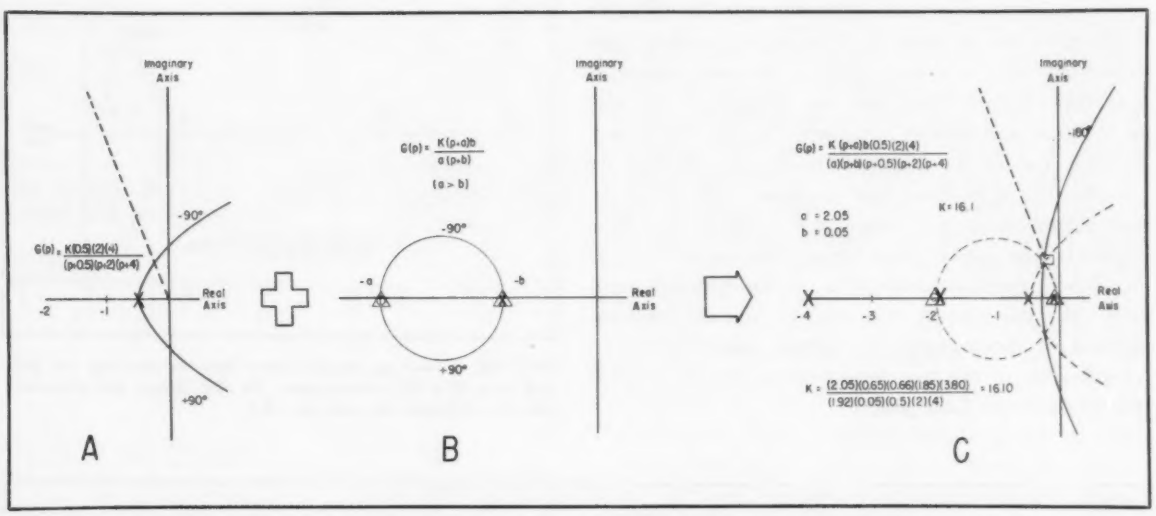


FIGURE 138—Adding the 90° phase angle loci of the example to the 90° phase angle loci of the controller will result in the 180° root locus. In the last plot the coincidence is made to occur at a point where $\delta = 0.36$.

bination of a certain phase loci of the process (say a phase loci of 30°) with the proper phase loci of the controller (in this case, 150°) when added to this plot will yield the required 180° root locus. Let us again consider our example.

If one plots the 90° phase angle loci of the example and adds to it the 90° phase angle loci of the controller (notice this is conveniently a circle), the 180° root locus will again result. There is, however, a restriction that we would like to meet. This is that the resulting closed loop pole should lie on the constant δ line corresponding to $\delta = 0.36$. We should then first construct the constant δ line on the 90° phase angle loci of the example as shown in the first part of Figure 138. We then shift the 90° phase angle loci of the controller (center section of Figure 138) back and forth along the axis until the two 90° loci intersects the $\delta = 0.36$ line (i.e., $-90° - 90° = -180°$, a point on the root locus). We then have the correct location of the lag compensator for an optimum root locus. The final root locus for this example is shown in the last section of Figure 138. Notice the much higher gain achieved with the optimum location of the lag. This allows the system to respond in an optimum manner in the shortest possible time.

TO BE CONTINUED

Heater tests reveal . . .

Tube Location Is Key to Performance

The most important variable in heater performance is the clearance between the tube-bank and furnace wall

H. M. Mathis, J. L. Schweppe and R. N. Wimpress
C F Braun & Co., Alhambra, Calif.

RESEARCH ENGINEERS have uncovered some of the answers to a long-standing question. How can you design a fired-heater so as to improve its performance without raising its cost? The trick is to locate and space the tubes properly. This article describes the tests that led to this conclusion.

Design Criteria. Two of the most important considerations in the design of a fired heater are average heat-flux and maximum heat-flux. The average heat-flux determines the size of the heater, therefore its cost. The maximum heat-flux, the fluid temperature, and the intube film coefficient, set the maximum tubewall-temperature. If this temperature is too high, the tube-wall may be weakened or the fluid may decompose. The result can be tube failure, or coking, or both. The goal of the fired-heater designer is to increase the average heat-flux without increasing the maximum heat-flux.

The only way to do this is to design for more nearly uniform heat-absorption rates—not only along the axis of the tube, but also around the circumference of the tube. But here the designer must strike a balance between performance and first-cost. The object of the Braun tests was to find out what variables are most important in trying to obtain uniform heat-absorption rates—and to pin down the effects of these variables.

Summary of Test Results. The tests show that the most important single variable is the clearance between the tube-bank and the furnace wall. As the tubes are moved away from the wall, the heat-absorption rate goes up. The improvement in performance is consistent for different sized tubes only when the clearance is expressed in inches—not in tube-diameters.

The distribution of heat around a tube is more uniform for widely spaced tubes than it is for closely spaced tubes. This is true for all locations of the tube-bank—but particularly when it is at a minimum distance from the furnace wall. Consequently the improvement in performance made by moving the tubes away from the wall is less for widely spaced tubes than for closely spaced tubes.

The heat distribution seems to be somewhat more uniform around larger tubes. The orientation of the tubes—horizontal or vertical—does not affect the performance.

FIGURE 1—Special heater allows four variables for the tests.

Test Equipment. A specially designed heater, Figures 1, 2, 3, and 4, was used for the series of tests. The heater was so constructed that four things could be varied: tube-to-wall clearance, tube-to-tube spacing, tube size, and tube-orientation (horizontal or vertical). The area under study was the radiant section of the heater. For all tests, the heater tubes were cooled with air inside the tubes. The heater was equipped for measurements of temperatures, fuel gas and air flows, pressures, and draft. The important design data are tabulated in a table on next page.

Test Methods. For each test, two things were kept constant: firebox temperature and average tubewall temperature. The average heat-absorption rate per square foot of exposed tube-area was computed. Then, when the variables were changed for the next test, an

Tube Location Key to Performance . . .

increase in performance—that is, a higher average heat-absorption rate—could come only from a more uniform heat distribution around the tube. This method of testing made certain that the established maximum tubewall temperature would not be exceeded.

Tube-To-Wall Clearance Test. For this test, the wall coil consisted of six two-inch IPS tubes spaced at 1.5 diameters center-to-center.

Figure 5 illustrates how the average heat absorption increases as the tubes are moved away from the wall. In this test, the heat absorption went up 19 percent when the tube-to-wall clearance was increased from 0.1-inch to 1-inch. It went up another 12 percent when the clearance was increased from 1 to 3 inches, and a further 9 percent when the clearance was increased from 3 to 7 inches.

Figure 6 shows how the heat distribution around the tube varies as the tube is moved away from the wall. The heat absorption at the front of the tube remains almost constant, but the absorption at the back of the tube increases rapidly with increasing clearance. The theoretical heat absorbed (radiant only) is shown on the figure for comparison.

A larger tube-to-wall clearance increases heat absorption only if the space behind the tubes is kept open. This was demonstrated by placing baffles between the back of the tubes and the furnace wall. The baffles nullify the effect of the tube-to-wall clearance, and reduce the heat absorption rate to what it would be if the tube-to-wall clearance were the same as the tube-to-baffle clearance. This is shown on Figure 5.

Analysis. The increased heat absorption at larger tube-to-wall clearances results from increased convection heat transfer. Normally, the fluegas within the combustion chamber circulates as a result of natural convection. The circulating currents move down the furnace wall as the gases are cooled by the wall and the tubes. The greater the circulation, the higher the convection heat-transfer rate. The results given here confirm earlier observations by Reed.[2, 3]

Since the fluegas flows in the restricted space between the tubes and the wall, the major increase in heat input occurs on the side of the tube next to the wall. This shows clearly on the heat distribution curves of Figure 6. When baffles are present, the heat distribution around the tube corresponds very closely to the heat distribution for the same net clearance when baffles are not present.

Tube-To-Tube Spacing Test. For this test, two different wall coils were used—2-inch IPS tubes at 1.5 diameter spacing, and 2-inch IPS tubes at 2.5 diameter spacing.

Figure 7 shows how the two different tube-spacings compare in heat absorption, expressed as a percentage of the theoretical radiant-heat absorption. The heat absorbed is always greater than theoretical because of

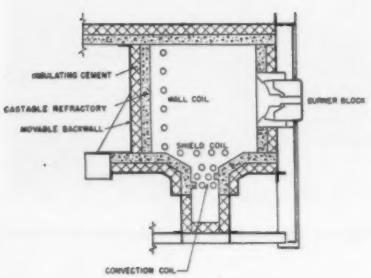


FIGURE 2—Test heater cross-section shows radiant section under study.

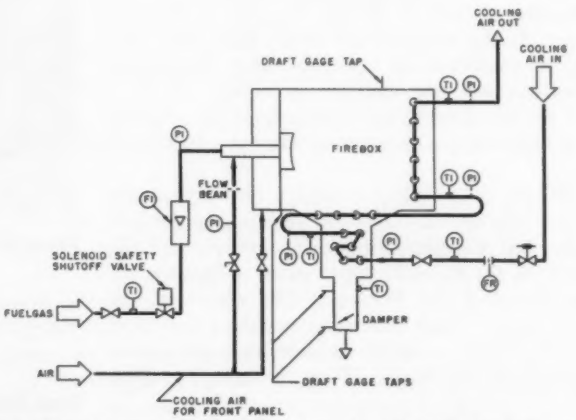


FIGURE 3—Flow diagram of test equipment. Cooling air keeps average tubewall temperature constant.

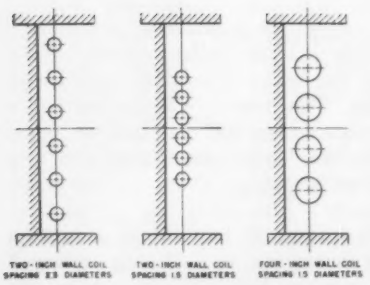

TWO-INCH WALL COIL SPACING 2.5 DIAMETERS
TWO-INCH WALL COIL SPACING 1.5 DIAMETERS
FOUR-INCH WALL COIL SPACING 1.5 DIAMETERS

FIGURE 4—Furnace coil arrangement allows tube diameter and spacing study.

DESIGN DATA

Box Size	3 x 3 x 3 Feet
Total Refractory Area	54 Square Feet
Mean Length, Radiant Beam	2 Feet

TUBE DATA	RADIANT COILS				SHIELD COIL
Tube Orientation	**Hor**	**Hor**	**Vert**	**Hor**	
Tube Size, IPS	2	2	2	4	2
Spacing, In.	3	6	6	6	4
Number of Tubes	6	6	6	4	4
Outside Area, Ft²	12.03	12.63	11.12	16.04	8.25
Ratio, Spacing/OD	1.5	2.5	2.5	1.5	2.0
α	0.96	0.79	0.79	0.96	0.88
A_{ep}, Ft²	5.45	9	7.78	6.75	4.75
αA_{ep}, Ft²	5.23	7.12	6.15	6.49	4.18

the convection heat-transfer. And with minimum tube-to-wall clearance, the percentage above theoretical is about the same for either spacing. But as the clearance is increased, the percentage above theoretical goes up more for the closely spaced tubes than it does for the widely spaced tubes. The reason may be that the path for fluegas behind the tubes is more clearly defined in the case of the closely spaced tubes.

Figures 6 and 8 show the heat distribution around tubes spaced at 1.5 and 2.5 diameters. There are four curves for each figure. The inner curve is the heat distribution based on theoretical radiant-heat-transfer only. The remaining curves are for measured heat distribution at different tube-to-wall clearances. The theoretical distribution of radiant-heat input is more uniform at 2.5 diameters spacing, as is the observed distribution. Both figures show clearly how convective-heat input improves the heat distribution around the tube.

Tube-Size Test. For this test, two different wall coils were used—2-inch IPS tubes and 4-inch IPS tubes, both horizontal at 1.5 diameter spacing.

The effect of tube diameter on heat absorption is shown in Figure 9. The broken curve is corrected for differences in the design constants of the two wall coils. Figure 9 shows that the tube diameter has practically no effect on the average heat-absorption when the

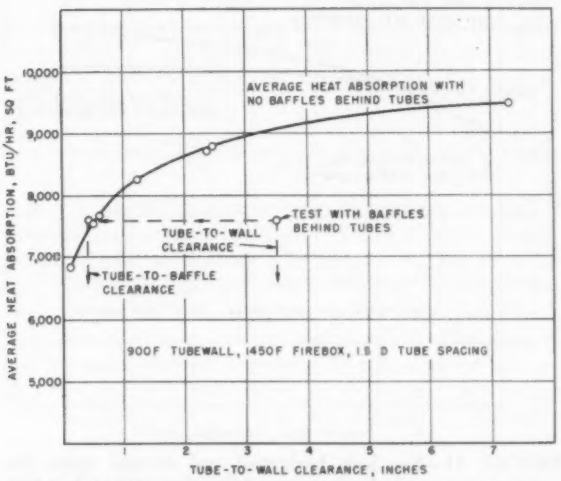


FIGURE 5—Average heat absorption increases as tubes are moved away from the wall.

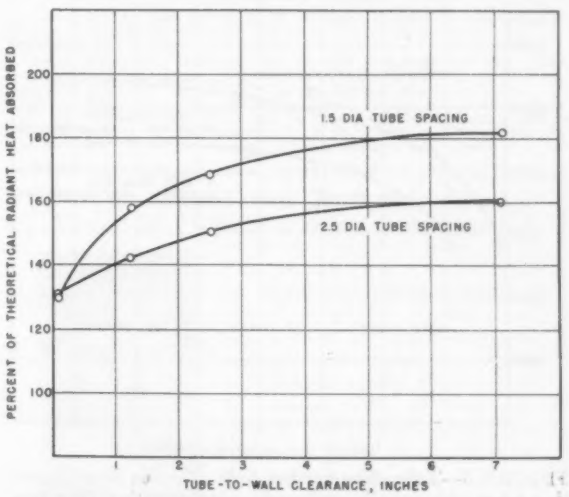


FIGURE 7—As clearance is increased, percent heat absorbed above theoretical goes up.

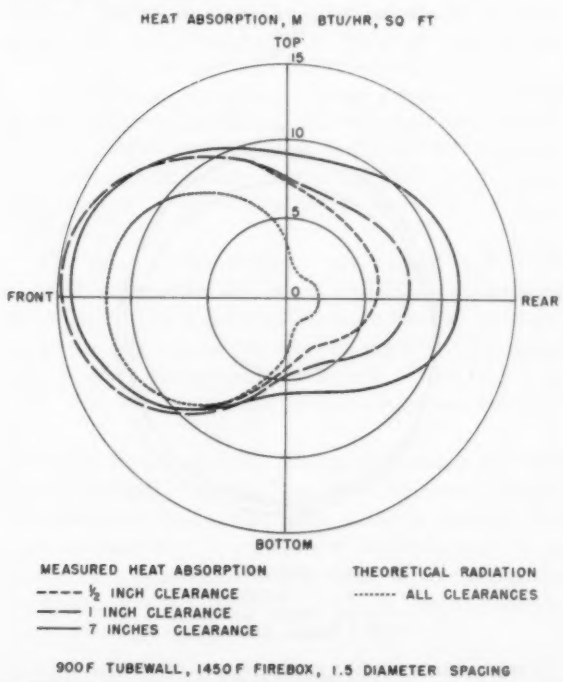


FIGURE 6—Heat absorption at back of tube increases rapidly as tube is moved away from wall.

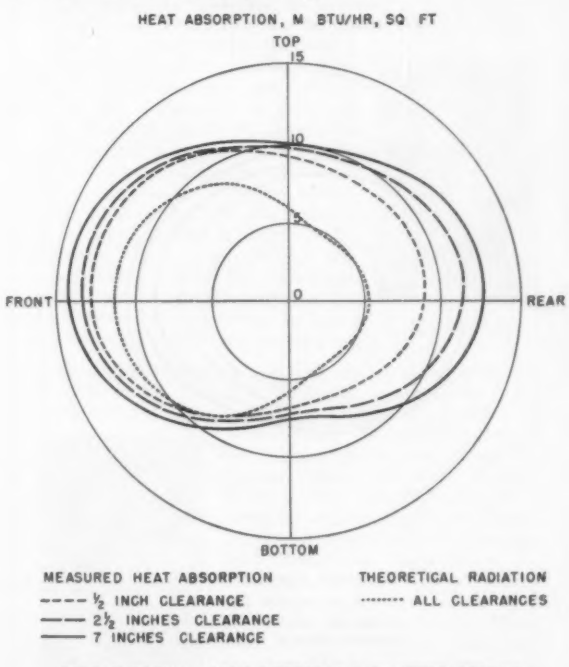


FIGURE 8—Heat distribution at 2.5 diameter spacing is more uniform than at 1.5 diameters.

Tube Location Key to Performance . . .

tube-to-wall clearance is measured in inches rather than tube-diameters.

Figures 6 and 10 show the heat distribution around two-inch and four-inch tubes. The distribution around the larger tube appears to be more uniform for all tube-to-wall clearances.

Tube-Orientation Test. For this test, a coil of 2-inch IPS tubes at 2.5 diameter spacing was oriented two ways—horizontally and vertically.

Increased tube-to-wall clearance improves the heat absorption to both horizontal and vertical tubes. Figure 11 shows the effect of clearance for both orientations. For both horizontal and vertical tubes, the major gain is made by increasing from minimum clearance to about 3 inches clearance.

For both orientations, increased tube-to-wall clearance improves heat distribution. The results show in Figures 8 and 12. The distribution of heat around the vertical tube is not the same as the distribution around a horizontal tube, but the general observations are the same.

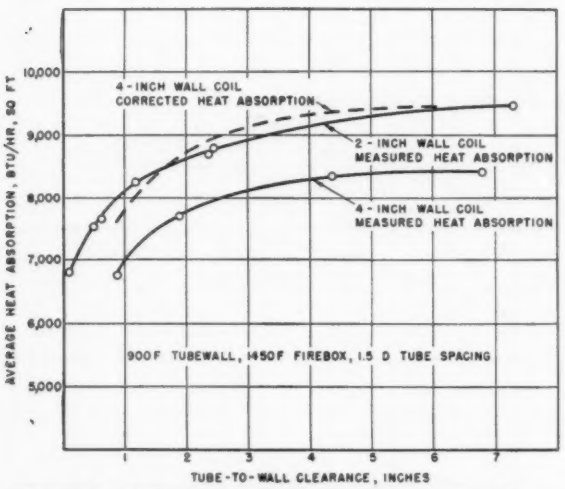


FIGURE 9—Tube diameter has little effect on heat absorption when clearance is measured in inches rather than tube diameters.

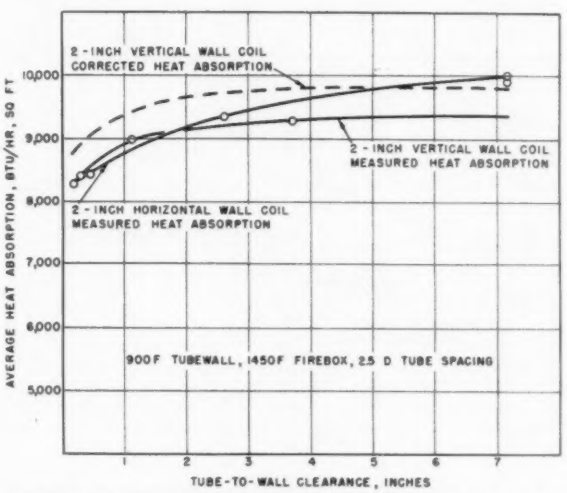


FIGURE 11—For both horizontal and vertical tubes, the major gain is made by increasing min. clearance to 3 inches.

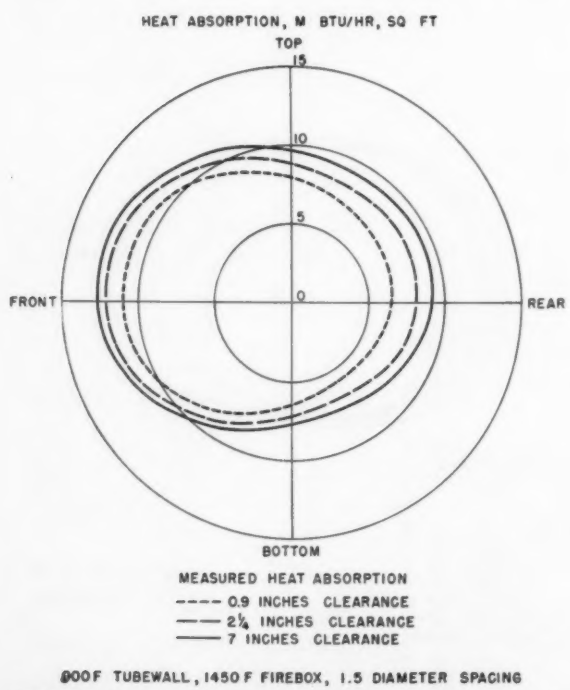


FIGURE 10—The heat distribution for a 4-inch pipe is more uniform than for a 2-inch pipe.

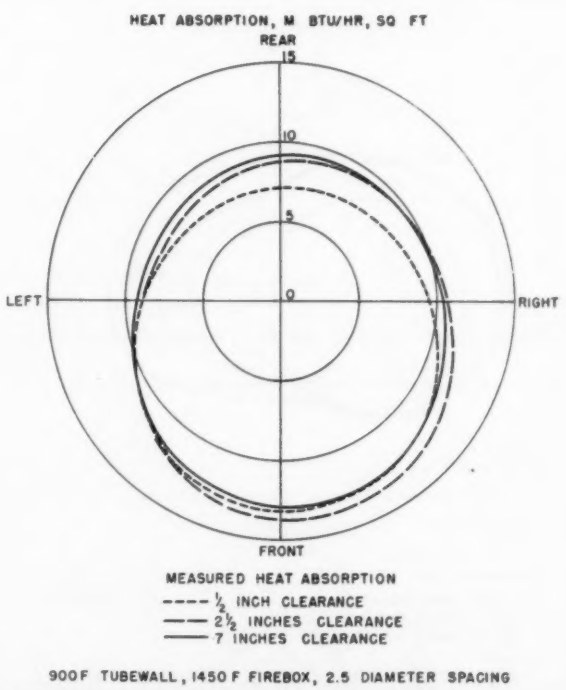


FIGURE 12—The heat distribution is different around vertical tubes but general observations are the same.

Theory. The net transfer of radiant energy between a hot gas and a bank of tubes can be expressed by a modification of the Stefan-Boltzman equation.

$$q_r = \sigma \alpha A_{cp} F (T_g^4 - T_t^4) \qquad (1)$$

The difference in the absolute temperatures to the fourth power multiplied by the Stefan-Boltzman constant σ, is the net interchange of radiant energy between infinite surroundings and a unit area. The terms $\alpha A_{cp}F$ account for the area of the receiving surface, and the difference between radiation in the furnace and black-body radiation. The term F in Equation 1 is called the radiant exchange factor.[1] This factor is a function of the gas emissivity and the ratio of effective refractory to equivalent cold plane area.

Heat transfer in the radiant section of fired heaters is not confined to radiation. Some heat is transferred by convection. If the exchange factor, F_T, includes both radiation and convection effects, Equation (1) may be rewritten as follows.

$$\frac{q_T}{A} = \frac{\sigma \alpha A_{cp} F_T}{A} T_g^4 - \frac{\sigma \alpha A_{cp} F_T}{A} T_t^4 \qquad (2)$$

For a particular heater operating at a given set of conditions, the exchange factor, F_T, is directly proportional to heat absorption. The terms αA_{cp} are fixed for any specific heater. And, for a constant value of tubewall temperature, F_T is constant. For these conditions, Equation (2) is a straight-line relation. The plot of q_T/A versus T_g^4 at constant T_t has a slope of $(\sigma \alpha A_{cp} F_T)/A$. At a zero value of q_T/A, the plot passes through T_t^4. This plot and the method of averages[4] were used to smooth the experimental data.

Evaluation Methods. The total heat absorbed by the radiant tubes was determined from the measured flow-rate of cooling air, and the inlet and outlet temperatures. This quantity, divided by the total exposed tube surface, gave the average absorption-rate.

The radiating temperature of the gas was calculated as the arithmetic average of the temperatures indicated by four thermocouples located in the firebox. Although this average temperature may not be the true radiating-temperature, it is satisfactory as a basis for comparisons.

The tubewall temperature was measured by four thermocouples imbedded in the wall of the center tube of the coil. The thermocouples were located at 90-degree intervals around the tube, on the front, top, back, and bottom. The arithmetic average of the four temperatures was used as the effective tubewall temperature.

The variation in heat absorption around the tube was calculated from the four tubemetal temperatures, the measured fluid-temperature, and the average rate of heat absorption. The effects of circumferential heat-conduction were taken into account in converting the measured temperature-differences to relative absorption-rates.

ACKNOWLEDGMENTS

The Braun fired-heater research project was started under the direction of L. B. Sutherland. Mechanical design was by R. G. Cushman.

NOMENCLATURE

- A is the total tube area, square feet
- A_{cp} is the projected area of the tube bank, square feet
- F is the radiant exchange factor
- F_T is the over-all exchange factor
- q_r is the radiant heat transfer rate, Btu/hr
- q_T is the over-all heat transfer rate, Btu/hr
- T_g is the fluegas temperature at the exit from the radiant section, °R
- T_t is the average tubewall temperature in the radiant section, °R
- α is the factor of comparison between a tube bank and a plain wall
- σ is the Stefan-Boltzman constant in appropriate units

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About the Authors

H. M. Mathis

Howard M. Mathis is a project engineer for C F Braun & Co., Alhambra, Calif. With the company since 1946, he has served as a chemical engineer and as a project engineer, and spent time in the field both in construction and engineering. Previously associated with E. I. du Pont de Nemours & Co. at Deepwater, N. J., he now is registered as a professional engineer in California. Mathis is a chemical-engineering graduate from Drexel Institute of Technology.

J. L. Schweppe

Dr. Joseph L. Schweppe is chairman of the Chemical Engineering Department at the University of Houston, where he is both a teacher and a consultant. He holds B.S. and M.S. degrees in chemical engineering from the University of Missouri and received his Ph.D. degree in 1950 from the University of Michigan. A registerd professional engineer, he was in technical service work at E. I. du Pont de Nemours & Co.'s Sabine River works, Orange, Texas, from 1949-52. Until January, 1958, Dr. Schweppe was a senior project engineer for C F Braun & Co., where he spent six years in research and engineering.

R. N. Wimpress

R. N. Wimpress is a senior chemical engineer for C F Braun & Co., Alhambra, Calif., where he is responsible for the chemical engineering portions of chemical-plant and refinery design. He has a B.S. degree in applied chemistry from California Institute of Technology and M.S. degree in chemical engineering from Massachusetts Institute of Technology. With Braun for eight years, he has been a research engineer, chemical engineer, and supervisor of a fired-heater research group. Wimpress had previously been with Standard Oil Co. (Louisiana), Cal Tech, and Industrial Engineers, Inc.

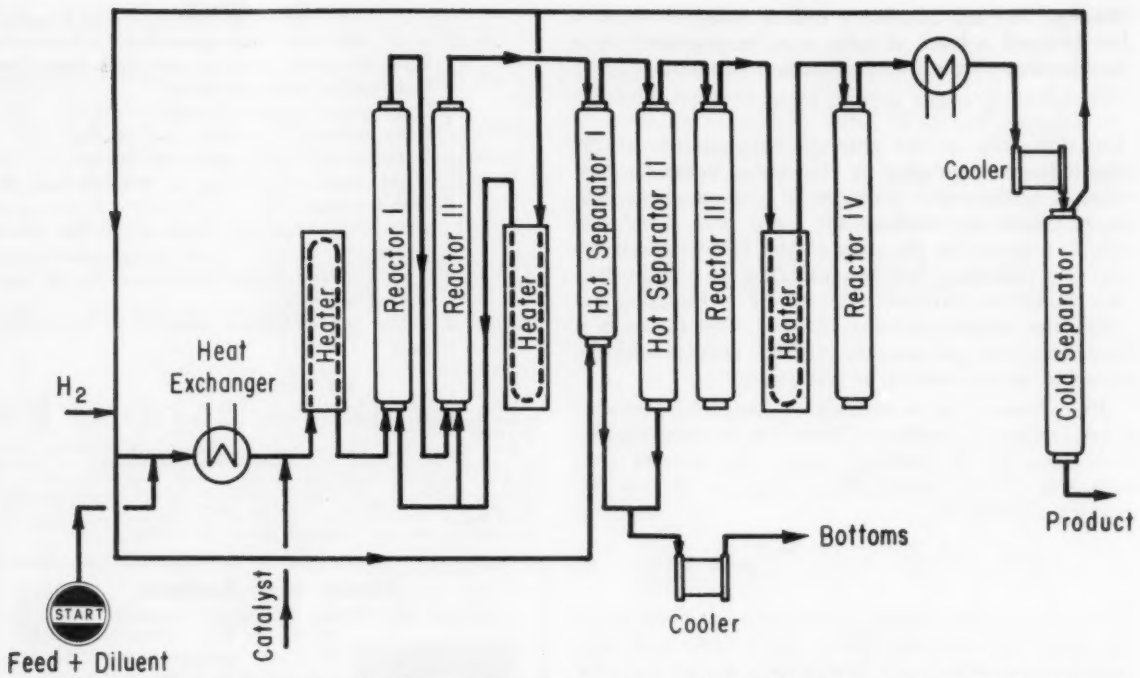

FIGURE 1—The process not only hydrocracks high asphalt crudes and their residues, but also shale oil and coal tars.

Hydrocracking Tried on Larger Scale

Now a commercial size unit is used to crack asphaltic crudes in the presence of hydrogen and a catalyst. The process operates at lower pressures and temperatures than many other hydrogenation methods

J. Varga, J. Károlyi, P. Steingaszner, A. Zalai, R. Birthler and Gy. Rabó, Nagynyomasu Kiserleti Intezet, Budapest

THE VARGA PROCESS serves primarily for hydrocracking high asphalt crudes and their residues. However, hydrocarbons from other origins such as shale oil and coal tar can also be processed efficiently with it.

One of its main features, the process hydrogenates a crude to a lighter product with a cheap catalyst suspended in a liquid phase. The process differs from other hydrogenating methods by diluting the charge with light oils so that lower process temperatures and pressures may be used.

A previous article[1] describes the development in laboratory and pilot plant equipment. The present discussion will extend the earlier article and will include commercial operations of the process, carried out in the V.E.B. Kombinat "Otto Grotewohl", Böhlen, GDR.[2]

The flow diagram of the commercial plant having a capacity of 120,000 tons per year (about 2,200 bpd) is shown in Figure 1. This plant was rebuilt recently for experimental purposes.

Unlike the single-reactor pilot plant, the industrial-size plant has two liquid-phase hydrogenation reactors. The reaction products flow from these to two separators. The main stream remains in the vapor-phase and is sent then to a two-stage fixed-bed hydrodesulfurization system. In this way, the process is more economical since treating can be performed without extra compression and reheating.

PROCESS HANDLES HIGH ASPHALT CRUDE

The high-asphalt and high-sulfur Transdanubia crude used in the industrial-scale process is the same as described before.[1] Test data for the

crude are summarized in Table 1.

The crude is mixed with an equal portion of a Diesel fuel distillate having 0.840 density and a boiling range of 410°-625° F. The mixture is hydrocracked in the presence of hydrogen equivalent to 4 weight percent of the charge mixture.

TABLE 1—Properties of Transdanubia Heavy Crude

Specific gravity at 25° C, gm/ml	0.947
Sulfur, Wt. %	3.2
Conradson residue, Wt. %	14.3
Water, Wt. %	1.7
Product Distribution and Properties of the Cuts	
Gasoline (375° F, cut point), Vol. %	4.4
Specific gravity at 25° C, gm/ml	0.730
Sulfur, Wt. %	0.1
F-2 Octane Number, clear about	30
Gas Oil (375°-715° F), Vol. %	17.8
Specific gravity at 25° C, gm/ml	0.872
Sulfur, Wt. %	1.8
Conradson residue, Wt. %	0.1
Cetane number, calculated about	60
Heavy Gas Oil (715°-930° F), Vol. %	30.3
Specific gravity at 25° C, gm/ml	0.933
Sulfur, Wt. %	2.7
Conradson residue, Wt. %	0.5
Vacuum residue (930° F and heavier), Wt. %	51.5
Specific gravity at 25° C, gm/ml	1.050
Sulfur, Wt. %	4.1
Conradson residue, Wt. %	30.8
R & B softening point, °C	60-80

TABLE 2—Hydrocracking of Transdanubia Oil in an Industrial Size Plant

Fraction	Wt. %
Gas formation + losses	3.2
Gasoline (375° F, cut point)	12.1
Gas oil (715° F, cut point)	63.3
Heavy gas oil (930° F, cut point)	6.6
Residue*	20.7
Hydrogen consumption	1.9

* Including also spent catalyst.

TABLE 3—Test Data of the Tuimasa Atmospheric Residue

Specific gravity at 25° C, gm/ml	0.934
Asphalthene content (insoluble in n-hexane), Wt. %	1.8
Conradson carbon, Wt. %	8.4
Vacuum residue (over 615° F) at 10 mmHg), Wt. %	53.0
Elementary analysis, Wt. %	
C	85.85
H	11.87
S	1.88

TABLE 4—Hydrocracking Tuimasa Atmospheric Residue. (Yields Based on Atmospheric Residue)

	Wt. %
Gas formation + losses	8.2
Gasoline (375° F cut point)	9.9
Specific gravity at 25° C, gm/ml	0.745
F-2 Octane number	65.5
Sulfur, Wt. %	0.05
Gas Oil (70% point at 625° F)	54.4
Specific gravity at 25° C, gm/ml	0.840
Flash point (enclosed cup) °C	87
Setting point, °C	−5
Diesel index	50
Sulfur, Wt. %	0.15
Heavy gas oil (970° F cut point)	14.2
Vacuum residue	16.6*
Total	103.3*
Hydrogen consumption	2.4

* Including 0.9% spent catalyst + 0.2 % coke formation.

The mixture of crude and diluent is fed into heat exchangers by using plunger-pumps. Compressors circulate recycle-gas into the heat exchangers. The catalyst paste, containing 40-50 percent by weight of catalyst-powder, was pressed by a steam-driven high pressure plunger pump to the stream leaving the heat exchanger.

The preheated mixture of raw material, diluent, recycle-gas and catalyst paste, was heated to reaction temperature in a convection heater. Actual hydrocracking proceeded in the two liquid-phase reactors connected in series.

The product leaving the second liquid-phase reactor goes into the two separators in series, where the heavy oil containing catalyst separates from the lighter distillates. Two separators are used to assure no asphaltic materials nor hydrocracking catalyst are carried-over into the treating section. The heavy oil is withdrawn from the system after being led through a cooler and expanded through a valve having tungsten-carbide-inserts.

The lighter distillates, together with the recycle-gas, enter the two hydrodesulfurization reactors charged with fixed catalyst. After leaving the first treating reactor, and before entering the second one, the stream is heated to the required temperature in an intermediate heater. The stream leaving the second treating reactor, passes through the feed heat-exchangers and a double-pipe cooler into another separator where recycle gas and liquid products are separated. The lighter hydrocarbons are scrubbed from the recycle-gas in an absorber. Make-up hydrogen is supplied with a purity of more than 97 percent.

TABLE 5—Test Data for Shale Oil

Specific gravity at 25° C, gm/ml	0.8913
ASTM Distillation, °F	
IBP	412
5 Vol. %	491
10 Vol. %	536
20 Vol. %	586
30 Vol. %	626
40 Vol. %	656
50 Vol. %	678
60 Vol. %	687
Elementary Analysis, Wt. %	
C	84.45
H	12.36
S	0.43
N	1.18
O	1.58
Solids (insoluble in benzene), Wt. %	0.12
Fractional distillation, Wt. %	
355° F Cut point	1.2
465° F Cut point (10 mmHg)	49.0
615° F Cut point (10 mmHg)	34.3
Residue	14.4
Losses	1.1
Total	100.0

TABLE 6—Hydrocracking Shale Oil

Reaction Conditions:	
Pressure, Psia	1030
Temperature, °F	830
Space velocity, lb/(cu. ft.)(hr.)	62.4
Gas ratio, scf/lb	48
Yields Wt. %:	
Gas + losses	14.8
Gasoline	
Specific gravity at 25° C, gm/ml	0.727
Sulfur, Wt. %	0.04
ASTM Distillation, °F	
IBP	181
10 Vol. %	223
30 Vol. %	237
50 Vol. %	255
70 Vol. %	280
90 Vol. %	327
FBP	381
Jet-Fuel Component	24.0
Specific gravity at 25° C, gm/ml	0.809
Sulfur, Wt. %	0.04
Flash point, °F	133
ASTM Distillation, °F	
IBP	298
10 Vol. %	342
30 Vol. %	376
50 Vol. %	417
70 Vol. %	460
90 Vol. %	511
FBP	554
Diesel Oil,	37.3
Specific gravity at 25° C, gm/ml	0.835
Sulfur, Wt. %	0.087
Flash point, °F	203
Cetane number	48
Residue	10.1*

* Including the spent catalyst.

Large-scale hydrocracking of Transdanubia crude, with a space velocity of 69 lb/(cu ft)(hr), gas circulation rate of 22 cu ft/lb, pressure of 990 psia and temperature of 815° F yields the products represented in Table 2.

Product-gasoline has a low octane number and can be used for automotive fuel only after being reformed. Diesel oil has a sulfur content of 0.16 percent by weight, Conradson carbon of 0.01 percent by weight and a measured Cetane number of 50. Heavy gas oil distillates can be used as catalytic cracking feed stock or as high quality fuel oil. The residue possibly filtered or centrifuged, can be used as a fuel for the production of hydrogen or as a coking promoter additive or it can be processed by means of fluid coking.

The catalyst for hydrocracking is an activated brown-coal semi-coke, impregnated with ferrous sulfate and sodium hydroxide, the same as is used for the classic high-pressure sump-phase hydrogenation[3]. It is

TABLE 7—Utility and Chemical Requirements. (Basis: Processing One Barrel Transdanubia Crude)

Fuel gas, M Btu	240-270
Electricity*, Kwh	21-23
Cooling water (at 60° F), gal	600
Hydrogen (97%), scf	7100
Catalyst, lb/bbl	13

* All motors driven electrically.

produced at the V.E.B. Leunawerke "Walter Ulbricht", Leuna, GDR.

HYDROCRACKING TUIMASA OIL

Crudes of lower asphalt and sulfur content, can also be processed by means of hydrocracking. Such a crude is the Tuimasa crude (Soviet Union) having a density of 0.850 at 25° C, sulfur content of 1.08 percent by weight and a Conradson carbon of 4.15 percent by weight. It yields by atmospheric topping about 18 percent by weight of gasoline and 37 percent by weight of gas oil. **In a pilot plant,** the 50 percent residue obtained from Tuimasa mineral oil, was hydrocracked after being diluted with kerosine distillate in the ratio of 4:1. with 0.8 percent by weight of catalyst (based on the quantity of atmospheric residue), at a pressure of 1030 psia, reactor temperature of 815° F, and a space velocity of 62 lb/(cu. ft.)(hr.). The product vapors were then hydrogen treated in a fixed bed reactor. Test data of the atmospheric residue are summarized in Table 3, while quality and yield of the products are shown in Table 4.

These data prove the atmospheric residue can be processed at a relatively low hydrogen consumption of 2.0 percent by weight, into 8.0 percent by weight of gasoline and 61.5 percent by weight of gas oil. Naturally, gasoline still needs reforming, however, gas oil can be applied as diesel oil without any further refining. The amount of heavy gas oil distillate was reduced to 12.8 percent by weight; it can be utilized as fuel oil or as feedstock of catalytic cracking. The vacuum distillation residue containing also the used catalyst, amounts to 11.8 percent by weight.

SHALE OIL CAN BE PROCESSED, TOO

By means of the Varga Process, shale oils can also be processed. Thus, a shale oil with test data summarized in Table 5, diluted with kerosine in the ratio of 70:30, was hydrocracked in the presence of an active coke powder catalyst of 3 percent in a laboratory-scale equipment consisting of liquid-phase and vapor-phase reactors. Reaction conditions as well as yields and quality of the products are shown in Table 6. These data show the shale oil can be cracked efficiently by means of hydrocracking.

In addition to shale oil, coal-tars also have been hydrocracked successfully in the same equipment.

ECONOMICS OF THE PROCESS

Economics of the process naturally depend on several factors. Utility requirements depend on quality of the material to be processed and on the severity of processing. These factors also affect the catalyst and hydrogen requirements. In Table 7, utility and chemical requirements are given for hydrocracking Transdanubia crude, one of the materials which is the most difficult to process.

The specific figures are approximate values. Data do not comprise energy and material requirements of the distillation plant nor of the hydrogen producing plant.

ACKNOWLEDGMENT

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About the Authors

Varga

Károlyi

Steingaszner

Zalai

Birthler

Rabó

Dr. Jozsaf Varga was director of the High Pressure Research Institute in Budapest, Hungary, before his death in December, 1956. He was a chemical engineering graduate of the Technical University, Budapest, and was the first in Hungary to work in high pressure hydrogenation.

Jozsef Károlyi is a chemical engineering graduate of the Technical University, Budapest, and is currently assistant director of the High Pressure Research Institute, Budapest.

Pal Steingaszner is a department head and pilot plant leader of the High Pressure Research Institute. He is a chemical engineering graduate of the Technical University, Budapest.

Andras Zalai is a department head doing research in catalysts for hydrocarbon processes at the High Pressure Research Institute. He graduated from the Technical University, Budapest, as a chemical engineer.

Dr. Richard Birthler is a department head of the reforming plant in Bohlen, Germany, near Leipzig. His work with this commercial unit includes a study of platinum catalyst and the medium pressure hydrogenation of brown coal tar middle oils.

Dr. Gyula Rabó is with Union Carbon Corp., Tonawanda Laboratories, N. Y. He was previously assistant director of the High Pressure Research Institute. He is a graduate chemical engineer, and has a Ph.D. degree in chemistry.

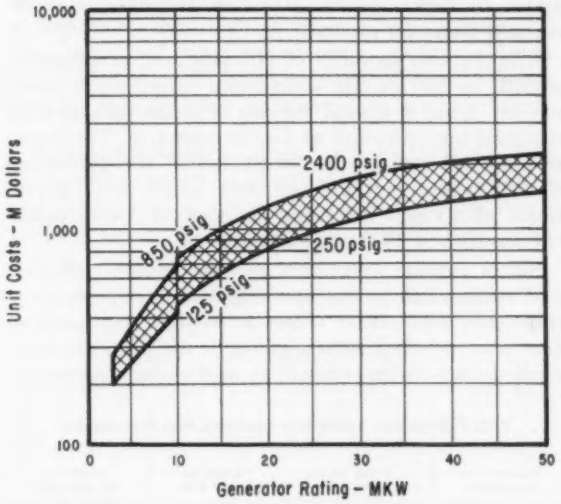

FIGURE 1—These costs are for turbine generator units which are non-condensing, non reheat, 3,600 rpm, 3-phase, 60-cycle, with steam superheat of 201°-300° F.

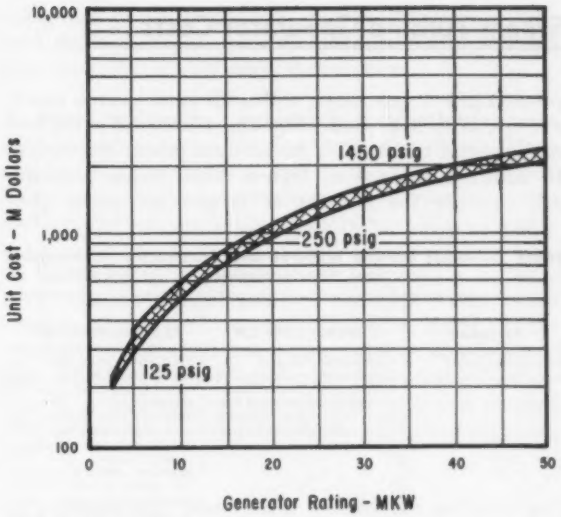

FIGURE 2—These are costs for condensing, non reheat turbine generator units at 3,600 rpm, 3-phase, 60-cycle and steam superheat of 201°-300° F.

Here's how to estimate . . .

Steam Turbine Generator Costs

These data permit rapid and accurate estimation of total installed costs of this important process utility item

N. H. Prater and D. W. Antonacci
The Chemstrand Corp., Pensacola, Fla.

ESTIMATING the capital investment required for installations of high-pressure extraction turbines—sometimes indicated for supplemental electric power needs—requires special knowledge and experience. Covered in the calculations here are turbine generator installations in sizes ranging from 2,500 kw to 50,000 kw and including sufficient data to enable the average process engineer to estimate costs with accuracy.

Process plant electricity, of course, may be purchased from a utility company or generated by steam-turbine-driven or internal combustion-engine-driven generators. A situation where process steam requirements are high (75,000 to 100,000 pounds per hour) indicates, according to economic studies, that such supplemental power should be generated through use of high-pressure extraction turbines.

Trend Toward Turbines. The use of industrial electric power has increased rapidly during the past ten years and, in many instances, without a corresponding increase in process steam usage. As a result, industrial generating plants are required to supplement the by-

Steam Turbine Generator Costs . . .

product power generation with additional electric power sources. Both non-condensing and automatic extraction turbines can be used for by-product power generation. In addition, the use of higher initial steam pressures will increase the amount of by-product power generated by steam turbine plants exhausting and/or extracting steam for process.

Initial steam pressures of 900 psig and temperatures of 825° to 900° F are widely used in industrial plants but the trend is toward the use of steam turbine units designed for operation at higher pressures. The steam turbine will remain the "work horse" for generating electric power in the foreseeable future and conventional plants now are being designed for steam conditions as high as 2400 psig and 1050° F.

Steam turbine generators provide flexible, efficient, and economical power for today's industry. Applications vary from those where maximum conversion of heat energy into electrical power is the prime requirement to those where electricity and varied amounts of

TABLE 1—Basic Turbine Features and Accessories (Condensing and Non-Condensing)

Turbine Part or Accessory	2,500 to 12,500 KW	12,500 to 50,000 KW
Emergency Inlet Valve	Combined trip and throttle valve, including switch to actuate main circuit breaker when turbine trip valve is closed to prevent generator from motoring.	Stop valve including, Provision for testing stop valve while unit is in operation. Solenoid trip. Spring support. Signal switches to indicate stop valve position (open closed, and test position). Switch to actuate main circuit breaker when turbine stop valve is closed to prevent generator from motoring.
Steam Strainer	Removable corrosion-resistant element integral with throttle valve	Removable corrosion-resistant element integral with throttle valve
Constant-speed Governor	Oil relay type	Oil relay type with manual load limit control
Steam Control Valve Gear	Automatic, multivalve	Automatic, multivalve
Overspeed Governor	Bolt type, independent of speed governor	Bolt type, independent of speed governor
Oil Level Indicator	Bayonet type	Float operated indicator with switch for alarm
Low Oil Pressure Protection	Governing valves will close loss of hydraulic oil pressure	Stop valve and governing valves will close with loss of hydraulic oil pressure
Operating Oil Gages	Two gages for main oil pump charge and main-bearing pressures	Two gages hydraulic system and main bearing pressures
Vapor Extractor	None	Motor-operated
Auxiliary Oil Pump	Steam turbine driven, with automatic pressure regulator	Steam turbine driven, with automatic pressure regulator
Turning Gear	None	Motor-operated, with motor-operated turning gear oil pump for bearings
Speed Indicator	Electric type consisting of tachometer-generator and indicating instrument	Electric type consisting of tachometer-generator and indicating instrument
Operating Steam Gages	Three gages for inlet, first stage, and exhaust pressures	Three gages for inlet, first stage and exhaust pressures
Thermometers	Stem type indicating thermometers and wells for main bearings and oil leaving oil coolers	Stem type indicating thermometers and wells for main bearings and oil leaving oil coolers
Shaft Packing Seal Control	Spray chamber with necessary piping from sealing glands to spray chamber —Motor-driven vacuum pump. For condensing units an automatic steam seal regulator with one steam pressure gauge furnished	Spray chamber with necessary piping from sealing glands to spray chamber —Motor-driven vacuum pump. For condensing units an automatic steam seal regulator with one steam pressure gage furnished
Exhaust Relief Diaphragm and Low Vacuum Trip	None	Furnished on condensing units Micro-switches for low vacuum alarm and to indicate trip has operated
Maintenance Tools	All special tools including box sledging wrenches for bolts and nuts 1¼ Inch and larger, eye-bolts, casing guide pins, jacking bolts and other tools depending on specific turbine construction	All special tools including turbine-casing lifting sling, box sledging wrenches for bolts and nuts 1¼ Inch and larger, eyebolts, casing guide pins, jacking bolts and other tools depending on specific turbine construction
Insulation and Lagging	Metal lagging for high temperature parts of turbine	Metal lagging for high temperature parts of turbine
Motor Insulation for Motor-driven Auxiliaries	Class "A" powerhouse insulation	Class "A" powerhouse insulation

TABLE 2—Basic Generator Features and Accessories

Feature or Accessory	2,500 to 12,500 KW	12,500 to 25,000 KW	25,000 to 50,000 KW
Enclosure	Totally enclosed	Totally enclosed	Gas-tight
Ventilation Medium	Air	Air	Hydrogen
Gas Pressure At 3300 Feet	Atmospheric pressure	Atmospheric pressure	30 psig
Cooling	Finned-tube surface gas cooler	Finned-tube surface gas cooler	Finned-tube surface gas cooler
Cooler Location	Mounted in generator housing	Mounted in generator housing	Mounted in generator housing
Cooler Materials	Admiralty metal tubes with copper fins, tube sheets of Munts metal and cast iron water boxes	Admiralty metal tubes with copper fins, tube sheets of Muntz metal and cast iron water boxes	Admiralty metal tubes with copper fins, tube sheets of Muntz metal and cast iron water boxes
Cooling Water Pressure	125 psig maximum	125 psig maximum	125 psig maximum
Cooling Water Temperature	95° F or lower	95° F or lower	95° F or lower
Voltage	2400/4160 volts	13,800 volts	13,800 volts
Power Factor	0.8	0.8	0.85
Short-circuit ratio	0.75 approximately	0.75 approximately	0.64
Stator Insulation	Class B	Class B	Class B
Stator Maximum Temperature	100° C by detectors	100° C by detectors	100° C by detectors
Field Insulation	Class B	Class B	Class B
Field Maximum Temperature	125° C by resistance	125° C by resistance	125° C by resistance
Collector Maximum Temperature	125° C by thermometer	125° C by thermometer	125° C by thermometer
Temperature Detectors: Embedded in stator windings	6	12	12
Cooler Outlet (s)	None	4	4
Cooler Inlet (s)	None (For generators with vertical corner coolers, one (1) detector for each cooler, for a total of 4)	None	4
Field Discharge Reactor	Furnished	Furnished	Furnished
Hydrogen Control	None	None	Seal oil control unit Hydrogen control cabinet. Portable CO_2 analyzer Gas dryer Hydrogen control manifold Water detector
Maintenance Tools (Also see Turbine sheet)	None	Rotor lifting sling and rotor skid with shims	Rotor lifting sling and rotor skid with shims

steam are required to meet process demands. In order to provide the best type of steam turbine generator to meet individual plant rquirements, generator manufacturers offer four principal types of turbine generators, all available in a wide range of capacity ratings:

1. Non-condensing types are ideally suited for generating electrical power in plants where exhaust steam is used for process or other lower pressure steam driven equipment. The turbine operates as a reducing valve, tying high-pressure boilers to systems utilizing low-pressure steam. Low cost power is then generated as a by-product and at a high thermal efficiency.

2. Non-condensing, automatic extraction turbines are used where steam for process or other steam driven equipment is required at two or more pressure levels. These units are the least common of the four basic types and usually find application only in special situations.

3. Condensing turbines are used primarily in applications where electrical power generation is the prime consideration. They are ideally suited to make up the variation in electrical power generated by non-condensing turbine as a result of changes in process steam demands. A higher plant cycle efficiency is also realized through the use of extracted steam for feed water heating.

4. Condensing, automatic extraction turbines are used where the flexibility of both the condensing and non-condensing turbine is required. This type is capable of accommodating fluctuations in electrical loads, independently of other sources of electrical power, while maintaining the desired frequency and providing variable quantities of process steam at controlled pressures.

Whatever the operating conditions, type of turbine and rating selected, the cost data presented will provide the high degree of accuracy needed in preparing capital cost estimates.

Steam turbine generator units represent a large capital investment and consist of a wide variety of standard features and accessories which are included in the base price of the unit. Because of the complexity of these units, the standard features and accessories are reviewed in Tables 1, 2, and 3.

The total manpower required to prepare the turbine generator foundation, material costs and total erection labor can be estimated using the data shown in Figure 3. The labor required for installing the unit includes the equivalent machine time for hoisting and setting the equipment based on an hourly rate of $7 per hour. The manpower required for preparing the foundation includes excavating, preparation of forms, placing reinforcing steel and concrete. Material costs include the usual cost of concrete, forms, reinforcing steel, anchor bolts and piling when required. The estimated weights of turbine generator units used in establishing these costs are shown in Figure 5.

TABLE 3—Basic Exciter Features and Accessories

Feature or Accessory	GENERATING MASTERS		
	2,500 to 12,500 KVA	12,500 and 25,625 KVA	25,650 to 50,000 KVA
Enclosure	Enclosed	Enclosed	Enclosed
Ventilation	Room cooled	Room cooled	Room cooled
Winding	Shunt	Shunt	Shunt
Maximum Field Temperature (40° C ambient)	80° C	80° C	80° C
Field Insulation	Class A	Class A	Class A
Maximum Armature Temperature (40° C ambient)	80° C	80° C	80° C
Armature Insulation	Class A	Class A	Class B
Maximum Commutator Temperature (40° C ambient)	95° C	95° C	95° C
Voltage	125 V	250 V	250 V
Field Rheostat	Hand operated	Motor operated	Motor operated
Temperature Detectors	None	None	1 for air entering and 1 for air leaving enclosure
Pilot Exciter	None	None	Motor-driven

There are many modifications to the standard features and accessories which can be added to the basic unit costs. The most common items which are encountered are listed in Table 5 along with the additional costs for their provision.

TABLE 4—Correction Factor for Temperature
(SH-Degree of Superheat)

Operating Steam Temperature Conditions	Pressure Range, Psig	Condensing Units	Non-Condensing Units
Saturation—49 SH	100—1,450	1.30—1.14	1.10—1.05
50 SH—99 SH	100—1,450	1.20—1.09	1.08—1.06
100 SH—200 SH	250—1,450	1.10—1.04	0.96—0.98
201 SH—300 SH	250—2,400	1.00—1.00	1.00—1.00
301 SH—349 SH	250—1,800	1.05—1.02	1.07—1.04
350 SH—400 SH	250—1,450	1.09—1.06	1.13—1.07

TABLE 5—Price Additions to Basic Unit Costs
(Add to Cost From Figures 1 and 2) Labor and Material, Dollars

	TURBINE GENERATOR RATINGS IN KILOWATTS						
	2,500	5,000	10,000	20,000	30,400	40,000	50,000
Weather Proof For Outdoor Installation	20,000	25,000	30,000	35,000	35,000	37,500	42,500
Supervisory Instrument Panel	15,000	15,000	15,000	15,000	15,000	15,000	15,000
Single Automatic Extraction Turbine	20,000	30,000	51,000	80,000	115,000	145,000	175,000
Double Automatic Extraction Turbine	50,000	75,000	145,000	220,000	325,000	415,000	515,000
Voltage Other Than Standard:							
480	3,000	.....			Not Available		
600	1,000	5,000			Not Available		
6,900	15,000	12,000			No Addition		
11,500—13,800	13,000	15,000			No Addition		
Twin Oil Coolers, 100—105° F Cooling Water	3,500	3,750	5,000	7,000	9,000	11,000	13,000

The cost of appropriate steam condensers to serve the condensing type turbine generator units are shown in Figure 4. The condenser size required for each application must be analyzed for each case independently since available cooling water temperature, steam pressure and the heat load are the prime considerations in selecting the condenser size. The condenser costs include freight and supervision during erection. These costs include a steel plate condenser and water boxes, muntz metal tube plates, admiralty metal tubes, twin two stage

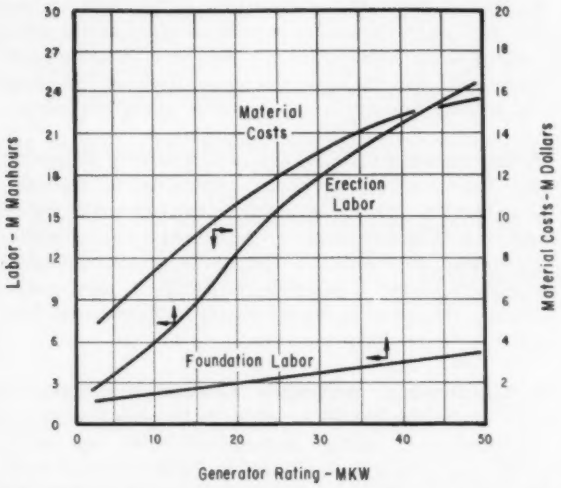

FIGURE 3—Shows condenser turbine generator installation costs which include all labor, materials and erection equipment charges. For non-condensing type, use 95 percent of these costs.

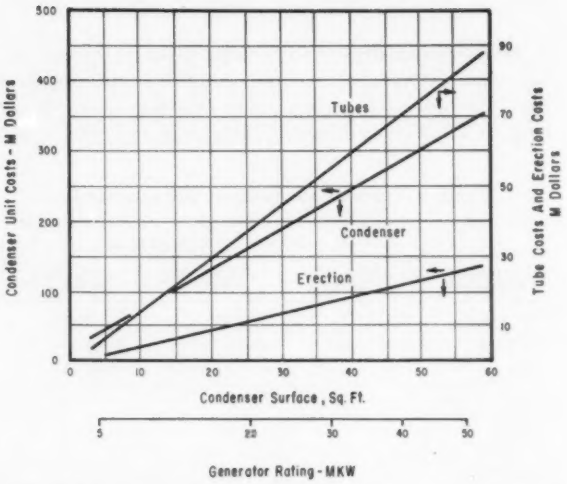

FIGURE 4—These installed condenser costs are based on 2 inch. Hg. absolute pressure and 80° F cooling water at a velocity of 7 ft./sec., 85 percent cleanliness factor and ¾ inch x 18 BWG tubes.

air ejectors, two motor driven condensate pumps, two motor driven circulating pumps, atmospheric relief valve, copper expansion joint, air meter, dual trap, hot well and primary ejector.

Examples below illustrate how the cost data presented is used for estimating the total direct installed cost for steam turbine generator units.

Example 1. Estimate the total direct installed cost for a non-condensing turbine generator having a capacity of 30,000 KW. The turbine will operate with 750 psig, 750° FTT inlet steam condition, and an exhaust steam pressure of 175 psig.

Turbine generator unit cost from Figure 1 is:	$1,350,000
Foundation costs from Figure 3:	
Labor: 4,000 manhours x $3.50/hour x 0.95	= $ 13,300
Materials: $13,000 x 0.95	= $ 12,350
Erection costs from Figure 3: 17,500 manhours x $4.00/hr. x 0.95	= $ 66,500
Price additions from Table V:	
Twin oil coolers	= $ 9,000
Supervisory Instrument Panel	= $ 15,000
Total Direct Installed Cost	= $1,466,150

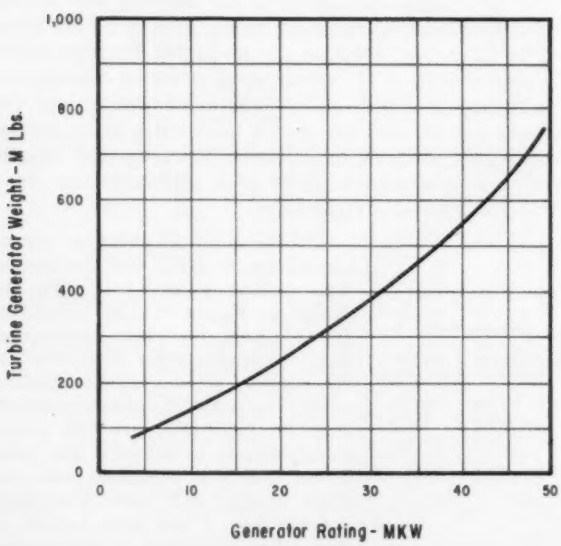

FIGURE 5—Estimated weights of turbine generator units can be taken directly from this chart.

Example 2. Estimate the total direct installed cost for a condensing single automatic extraction turbine generator having a capacity of 30,000 KW. The turbine will operate an inlet steam condition of 750 psig and 750° FTT.

Turbine generator unit cost from Figure 2:	= $1,400,000
Foundation costs from Figure 3:	
Labor: 4,000 man-hours x $3.50/man-hour	= $ 14,000
Materials:	= $ 13,000
Erection costs from Figure 3: 17,500 M.H. x $4/M.H.	= $ 70,000
Condenser Unit Size: 9.1 lbs. steam/KW x 30,000 KW / 8 sq. ft. condenser surface/lb. steam	= 34,125 sq. ft.
Condenser unit cost from Figure 4:	= $ 220,000
Condenser tube costs from Figure 4:	= $ 52,000
Installation cost, labor and materials also from Figure 4:	= $ 18,000
Price additions to basic unit from Figure 5:	
Single automatic extraction	= $ 115,000
Twin oil cooler	= $ 9,000
Supervisory Instrument Panel	= $ 15,000
Total Direct Installed Cost	= $1,926,000

Acknowledgment. The authors are grateful to the Allis-Chalmers Manufacturing Co. and The Elliott Co. for supplying data on turbine generator units. ##

These Factors Affect Plant Location

Here's how three factors—raw material concentrations, regional markets, and transportation gateways—are changing the economics of petrochemical plant location

Robert W. Gerwig
Midwest Research Institute
Kansas City, Mo.

ECONOMIC FACTORS which influence plant location decisions—observed changing in recent years—will eventually alter the production system toward a more decentralized and market-oriented network. Right now 80 percent of the production capacity is in the Gulf Coast area. The extent and timing of the effect of these changes is difficult to predict, and this analysis has been restricted to a review and measurement of historical trends.

- Raw materials prices are changing their relative position geographically. Natural gas is becoming more costly at its source and relatively more attractive at industrial market sites. Petroleum products prices have increased less than prices of natural gas.
- The choice of methods of transportation has been expanded. Chemical dodecene, solvents, LPG and aromatic stocks are batched through products pipelines and extension of batch pipelining appears economically feasible.
- Plants have been developed to produce certain petrochemicals on a small scale at costs which are competitive with large scale plants.
- Markets have grown.

Factors Changing. These changing factors will influence the choice of plant locations as determined by the two major cost differentials among locations (1) differences in the cost of transportation (of raw materials and products), and (2) differences in the cost of producing in plants of relatively small or large capacity which can be built to serve the plants' market areas.

Isard and Schooler completed a basic study of location factors in the petrochemical industry[1] in 1955 which is an excellent application of location theory to the industry. They compared the magnitude of two significant pulls (transport costs and economies of scale) for 62 different petrochemical products. This study also indicated the cost advantage of water shipment over rail shipment for these products. They concluded that the above two cost differentials constitute the only significant cost pulls for the regional location of the industry. Locational variation in plant and equipment costs, maintenance and cooling water cost, and process chemical costs (with some exceptions, such as chlorine) are comparatively insignificant. Differences among regions in fuel and steam costs reduce to differences of transport cost of the equivalent volume of natural gas. Additional considerations such as labor supply, extent of unionization, availability of utilities and services, taxes, etc. affect the choice of a location within the selected region.

The petrochemical industry showed signs of "maturing" in 1958. Decline in demand for many prod-

ucts combined with start-up of plants planned during the growth period 1955-1957 resulted in an excess of capacity. Consequently, the prices of many products have declined. This maturing process certainly does not mean that the industry has passed its period of growth. It is more probable that a transition is being observed from a very rapid rate of growth when profitable entry and expansion in the industry are easiest, to a more moderate rate, where entry and expansion must be more carefully planned to produce a profit. At the present time, increasing demand and general optimism about further increases point to another period of expansion.

Historically, growth of the petrochemical industry in number of products and volume has been remarkable. In 1957, 18 billion pounds of crude products from petroleum and natural gas were used in chemical conversion to produce 40.3 billion pounds of petrochemicals, 26 percent of the tonnage of all chemicals. The tonnage of petrochemicals will probably double between 1958 and 1965[2] indicating that a continuing high level of capital investment can be expected in this industry. A recent survey of capital spending expectations shows that the chemical industry expects to spend more on new plant and equipment in each of the next four succeeding years reaching a peak of $1,635 million in 1962.

The four economic plant location factors, which have been observed to be changing, examined individually, illustrate the extent and effect of the changes.

RAW MATERIAL PRICE TRENDS

The price of natural gas is expected to continue to rise relative to those of petroleum hydrocarbons, which will become increasingly attractive as petrochemical feedstock. An example of the effect of changing price relationships between natural gas and petroleum fractions is the rise in natural gas prices causing a current and projected shift from natural gas to petroleum sources for ethylene. Fifty percent of 1960 ethylene requirements will be supplied from petroleum fractions (propane-butane, etc.) compared with approximately 30-35 percent in 1957.

One of the principal factors in the concentration of the petrochemical industry in the Texas-Louisiana area has been the availability, at low cost, of natural gas and refinery off-gases. This area contains some of the richest natural gas deposits in the world and, during the period when pipe lines were under construction to deliver it to metropolitan and industrial markets, the abundant supply and discovery rate kept the well head price in these areas relatively low.

The Texas-Louisiana area contains 35 percent of the total U.S. refining capacity of 9 million barrels per day and, early in the development of refining technology, a large volume of low molecular weight by-product off-gases, of little value to the refiner, was available for chemical conversion. This was particularly true around refining centers such as Houston. These factors and others have since undergone changes which make gateway or market-oriented refining centers increasingly attractive as petrochemical plant sites.

The principal determinant of raw material prices for the petrochemical industry will continue to be the fuel demand for these hydrocarbons. Demand for chemical uses has a negligible effect upon the prices of most of the hydrocarbon raw materials. Chemical uses currently consume only 1.45 percent of the petroleum and natural gas hydrocarbons produced in the United States, and estimates for 1965 indicate that conversion to chemicals will increase to slightly less than 3 percent.

Natural Gas. Construction of pipe lines and the subsequent opening of new markets have caused the well head price of natural gas to increase. Reversal of the "Memphis Decision" by the Supreme Court has spurred plans for construction of natural gas pipe lines which will increase the demand for existing reserves. New pipe line construction has an immediate and considerable effect on available reserves, since the FPC requires that 20 years proven reserves be committed to supply new pipe lines before construction is approved. The price of natural gas has increased in producing areas over the past decade more rapidly than in consuming areas. See Table 1.

TABLE 1—Average Price of Natural Gas From Utilities and Pipelines for Resale (By Census Division)

	PRICE (CENTS PER THERM)		
	East North Central	West North Central	West South Central
Average, 1946–50....	1.82	1.69	0.71
1957.....	3.02	2.80	1.55
Percent increase, 1946–50 to 1957....	66	66	118

Source: *1958 Gas Facts* American Gas Association. Tables 97 and 117.

While the 1957 average wholesale price of gas (1.55 cents per therm) in the West South Central region (which includes the gas-producing areas in Louisiana, Texas and Oklahoma) is approximately half the average price in the North Central regions, it increased nearly twice as much over the last decade, indicating that natural gas price differentials between these areas are adjusting to reflect differences in transportation cost. The Oklahoma Natural Gas Co. reported that it bought gas at an average rate of 5 cents per Mcf in 1948 compared with 11 cents per Mcf last year, and a recent contract calls for an initial price of 16.8 cents per Mcf. Evidence of upward pressure on prices is inferred from the characterization of the natural gas market as a "seller's market" at present as contrasted to a "buyer's market" during the 1930's and 1940's.[5] The role and policy of the Federal Power Commission in controlling well head prices of natural gas have not yet been clearly established. The FPC has yet to establish standards for price determination after five years of operation subject to the Phillips decision. Some direction was provided by the Supreme Court which, in ruling in the CATCO case, specified that "initial price should be made a consideration of prime importance." One method of avoiding the restrictions and uncertainties of FPC regulation has been the sale of the gas fields rather than gas to pipe lines. This method is also favored

since a capital gains tax is paid rather than the higher corporate income tax.

Petroleum Products. Economical fuel uses have been developed for the off-gases which originally attracted the petrochemical industry to refinery concentrations. Polymerization and alkylation processes upgrade the off-gas into motor fuel blending stocks and cracking processes reduce the amount of fuel oil available for low cost fuel use. While the average price of natural gas in the West South Central region increased 118 percent, the wholesale price index (U.S. Bureau of Labor Statistics Index) of petroleum and products increased only 16 percent from the 1947-49 base period to 1957.

The price of domestic crude oil is limited to a great extent by the price of imported crude oil. Crude oil is readily transportable between continents, while application to tanker shipment of natural gas has only recently been proven feasible and will probably be restricted to transporting gas from low cost (Caribbean) to high cost (European) areas over the next decade. Imported crude oil is available to U.S. refiners at prices as much as 80 cents per barrel below the price of domestic crude, but is currently restricted to 17 percent of U.S. consumption. The government's policy on crude imports will be an important factor in determining the price of domestic crude oil (and products) over the next decade.

METHODS OF TRANSPORTATION

The preference of the petrochemical industry for Gulf Coast rather than Mid-Continent petroleum feedstocks must be credited mostly to the low cost transportation available in the Gulf Coast area which resulted in the concentration of refining there (although low cost raw materials also influenced these location decisions as indicated above). Access to the Gulf Intracoastal Waterway, Mississippi and Ohio Rivers, and ocean shipping lanes have made low cost transportation of bulk chemicals available to Gulf petrochemical producers, while Mid-Continent refinery centers are landlocked.

An important innovation by Continental Oil Co. recently proved the feasibility of pipe lining hydrocarbon chemicals over long distances. Dodecene is being shipping by Conoco through the Cherokee pipe line from Ponca City, Okla., to Wood River, Ill., with only 0.2 percent loss from a 20,000-barrel batch.[3]

The chemical industry has long envisioned shipment of chemical intermediates by pipe line. The development of this technique is of considerable importance to Mid-Continent refiners who aspire to diversity into production of chemicals, since it would nullify their transport cost disadvantage compared with plant sites on water transport routes. The savings in transportation costs obtainable by pipe line shipment compared with rail shipment is illustrated by comparing these costs between Tulsa and St. Louis. The tariff rate on products shipped through the Cherokee pipe line from Tulsa to St. Louis (Wood River, Ill.) is approximately 48 cents per barrel (1956) rate), or 0.16 cents per pound for benzene, while the cost of tank car transportation between these points is approximately 0.59 cents per pound. The cost differential is 0.43 cents per pound or 3.2 cents per gallon (10 percent of the market price of benzene).

Pipe Line Availability. Pipe line transportation of liquid petroleum products in the United States is handled through a petroleum products pipe line system that included 36,420 miles of trunk line in 1955. The limiting factors on batch shipment of hydrocarbon fuels through products lines have been reasonably well defined during many years of experience with this technique. The hydrocarbons handled in this manner have been limited largely to liquid fuels and liquefied petroleum gas, although reformer feedstock, mineral spirits solvents and dodecene have also been transported through products lines.

Present practice among pipe liners establishes the minimum batch size at 20,000-25,000 barrels. This batch size apparently originated from the experience of the Plantation Pipeline Co. in transporting batches of kerosine and diesel fuel.[4] The limiting factor determining minimum batch size in transporting fuels has been the degree of contamination that is allowable. Contamination would be a more serious limitation on chemical raw materials than on fuels.

It is significant to note some important conclusions from the operation of petroleum products lines which would tend to credit their use for transporting petrochemical raw materials. Minimizing commingling is an important economic consideration in the design of both crude and products lines, since batch shipment is common to the operation of both systems and mixing results in losses. Line length does not seriously limit application of the batch principle since the rate of commingling decreases with the distance traveled. Lines containing products as dissimilar as gasoline and kerosine have been temporarily shut down without excessive mixing. Pipe line companies make no extra charge for shipments of special products with which other products being shipped can be contaminated.

The feasibility of using pipe line transportation for hydrocarbons must include consideration of allowable contamination and cost of storage. These must be considered for each individual case. The contamination problem can be solved by finding other shippable products into which the commingled interface can be disposed, but trace contamination will be a special problem with many chemical intermediates. Aromatics will present special problems of swelling packing and gasket materials. Considerable research effort at Midwest Research Institute and other research laboratories is currently being directed to improving interface detection in pipe lining, and this research will eventually reduce the amount of contamination experienced in pipe line shipments. A system for handling inflated synthetic rubber interface spheres, which reduce commingling, has been developed and is being installed by Shell Pipe Line Co. on their Wood River-to-South-Chicago line at a cost of approximately $500,000. Texas Eastern Transmission Co. also is considering adapting this technique which was developed by the F. H. Malloney Co. of Houston.

SMALL SCALE PLANTS

The plant location pattern of a chemical process industry can be altered by development of new processes which are technically and economically feasible for a plant of

smaller capacity than was previously feasible. A recent example in petrochemicals was the development in about 1956-57 of "package plants" to produce polyvinylchloride (PVC). Previously, a few producers were producing all the PVC requirements of the plastics industry in plants ranging in capacity from 25-100 MM lb/year. Within two years after this development, 10 new producers had entered the market, mostly molders producing for their own requirements, with plants ranging from 6 to 25-MM-lb/yr capacity. As a result, production in the industry became much more widely dispersed.

One small scale plant to produce styrene by a new route from reformate was introduced by Cosden Petroleum Co. in Big Spring, Texas, in 1958. This may be a significant development to the plastics industry, since styrene monomer and polymer (particularly the latter) production has previously been largely controlled by two companies, The Dow Chemical Co. and Monsanto Chemical Co. The Cosden process is only economical on reformate which contains a high concentration of ethylbenzene in the C_8 fraction.

GROWTH OF MARKETS

Although demand for petrochemicals originates with the wants and needs of individual consumers, chemical products pass through several stages of manufacture before they become consumer goods. The market for petrochemicals is, then, an industrial market. Anhydrous ammonia is sold directly to farmers for fertilizer use after only one manufacturing step (from natural gas), but such exceptions are rare.

Consumption of petroleum-derived chemicals in several basic industry categories in the United States have been calculated by Midwest Research Institute for 1957 to indicate the size of these markets. See Table 2.

Three types of plant locations can be distinguished, locations oriented to (1) raw material concentrations, (2) markets, and (3) gateway or logical distribution points. The majority of petrochemical plants are located at raw materials sites in the Gulf Coast and Southwest areas rather than close to industrial markets which are concentrated in the Northeast (except synthetic fiber production, which is concentrated in the Southeast).

Decentralization Trend. Growth of the regional market for consumers' chemical products will eventually result in more decentralized production of petrochemicals. The decentralized production system for ammonia demonstrates the effect of growth of regional consumption to large tonnages. Over the next seven years, regional markets for petrochemicals will grow according to some unbalanced pattern that, in total, will result in a doubling of petrochemical consumption nationally.

More decentralized polymer converting industries (textiles, tires, films, etc.) should be looked for as the principal source of regional petrochemical market growth. Although no marked trend to decentralize conversion of fibers to textiles has as yet been observed, other polymer conversion industries (tires, detergents, molded plastics, film) are expanding away from their traditional centralized production centers in the northeast. This expansion is resulting in regional markets that will support polymer (and therefore monomer) plants of a size that is competitive with centralized production centers.

The foregoing does not mean that the costs have shifted enough to make market-oriented plants desirable for the majority of present expansion. The continuing expansion in the Gulf Coast area indicates that there is still a cost advantage for petrochemical producers located there. However, trends in costs of production and distribution indicate that the cost advantage of Gulf Coast producers is less than it has been in the past and a more decentralized production system will result if these trends continue.

TABLE 2—Major Petrochemical-Consuming Industries

Industry	Estimated 1957 U.S. Petrochemical Requirements (MM lb.)	Typical Petrochemicals Used
Plastics and Resins for:		
Molded and extruded goods[1]	1,289	21 families of compounds: vinyls, styrene resins, polyethylene, alkyds, aminos and phenolics together comprised 82.5% of the 1957 total
Paint, varnish and lacquer	787	
Film and sheet	485	
Adhesives and bonding resins	331	
Textile and paper conversion	185	
Organic noncellulosic fibers	470	acrylonitrile, aromatic derivatives, glycol
Synthetic rubber	2,002	styrene, butadiene
Detergents and other surfactants	1,123	dodecene, benzene, ethylene oxide
Plasticizers	442	phthalic anhydride, alcohols
Agricultural nitrogen (ammonia basis)	5,160	ammonia, urea

[1] Pipe, coated wire, housewares, tile, phonograph records, etc.

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About the Author

Robert W. Gerwig is a senior economist and project leader for chemical marketing research at Midwest Research Institute, Kansas City, Mo. He has a B.S. degree in chemical engineering from Iowa State College, M.B.A. degree from the University of Chicago, and is working toward a Ph.D. degree at the University of Chicago School of Business. Gerwig worked in applications research and sales for Hercules Powder Co. from 1952-55, and as a test engineer at White Sands Proving Ground from 1956-57. He has been with Midwest Research since 1958. Research leading to this article was sponsored by the Kansas City Power and Light Co.

Applied Hydrocarbon Thermodynamics

Part 16: Charts for Integral Method for Equilibrium Vaporization Calculations

Wayne C. Edmister
Oklahoma State University, Stillwater

THE INTEGRAL METHOD for petroleum fraction equilibrium vaporization calculations was given in Parts 14 and 15. This previous material will now be supplemented by: (a) comparisons showing the advantage of the integral method, and (b) new TBP transformation charts for estimating the true boiling point assays for equilibrium vapor and liquid.

Advantage of Integral Method. A few equilibrium flash vaporization calculations will show the advantage

TABLE 16.1—True Boiling Point Curve, Hypothetical Component Breakdown and Vapor Pressures for Petroleum Naphtha

Source: Thiele and Geddes, Ind. Eng. Chem. 25, 289 (1933)

No.	Boiling Point °F	HYPOTHETICAL "COMPONENTS"		TBP Curve Mol % Points	VAPOR PRESSURES mm Hg			
		Moles	Mol %		322 °F	355 °F	365 °F	435 °F
1	—135	2.67	0.3	0.2	165,000	191,000	197,000	259,000
2	— 49	21.80	2.7	1.7	64,000	77,500	79,000	114,000
3	12	19.13	2.4	3.0	32,600	40,000	42,700	61,100
4	32	47.75	5.9	8.4	30,500	34,700	36,200	54,300
5	97	56.90	7.1	14.9	16,500	19,750	20,700	35,200
6	153	70.34	8.7	22.8	7,350	10,200	11,100	19,500
7	207	86.00	10.7	32.5	3,630	5,200	5,800	11,300
8	254	83.90	10.3	43.0	1,950	2,890	3,220	6,520
9	298	68.55	8.5	52.4	1,050	1,625	1,825	3,940
10	340	62.50	7.8	60.6	580	940	1,060	2,480
11	369	44.22	5.5	65.9	374	620	710	1,710
12	393	41.68	5.2	72.5	256	437	507	1,290
13	415	45.45	5.7	77.9	181	315	369	1,000
14	435	37.36	4.6	83.0	131	234	275	760
15	453	35.72	4.4	87.6	99	180	212	600
16	472	31.42	3.9	91.7	72	132	156	468
17	492	24.88	3.1	95.2	52	99	119	364
18	517	21.13	2.6	98.1	32.5	64	77	250
19	547	4.39	0.6	98.6	18.2	37	46	160
		805.79	100.0					

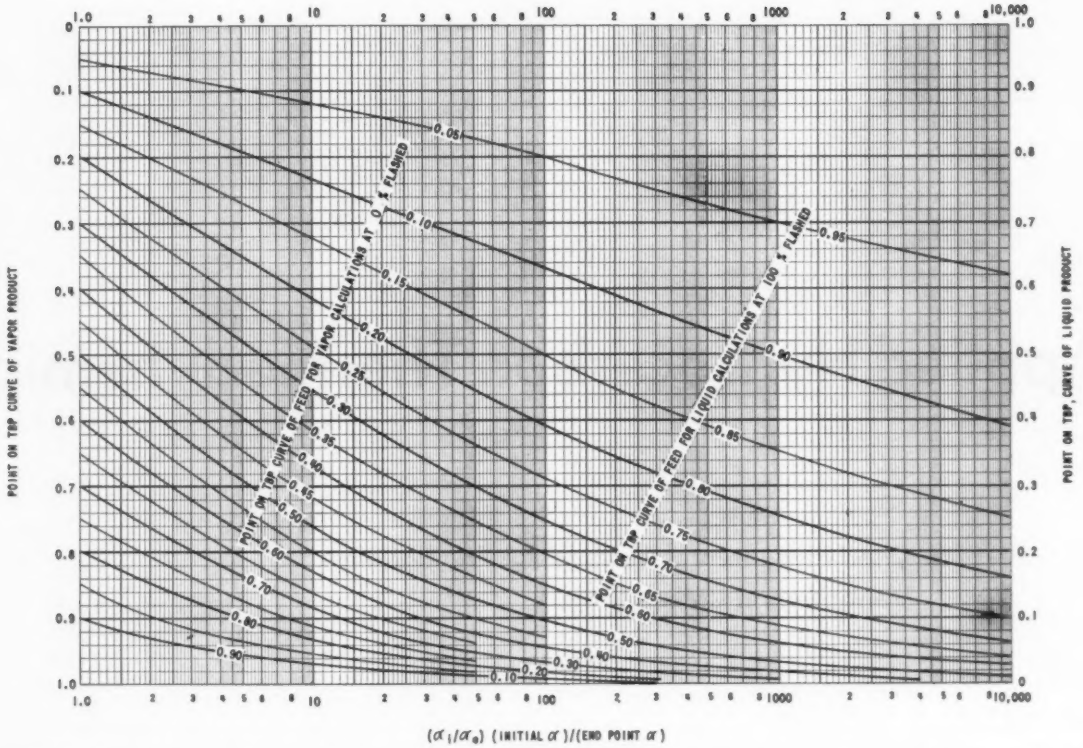

POINT ON TBP CURVE OF VAPOR PRODUCT
POINT ON TBP, CURVE OF LIQUID PRODUCT
POINT ON TBP CURVE OF FEED FOR VAPOR CALCULATIONS AT 0 % FLASHED
POINT ON TBP CURVE OF FEED FOR LIQUID CALCULATIONS AT 100 % FLASHED
(α1/α0) (INITIAL α)/(END POINT α)

FIGURE 16.1—TBP curves of equilibrium vapor at zero percent flashed and of equilibrium liquid at 100 percent flashed.

of the integral method. Using the data given in Table 16.1 for a petroleum naphtha, the V/L ratios were calculated at three temperatures for different mixture representation. The results, in Table 16.2, show that the mixture must be divided into more than 19 hypothetical components to approach the V/L values obtained for an infinite number of components, i.e., the "integral method."

The data in Table 16.1 give two representations of a petroleum naphtha. These are: (1) the molar quantities of 19 hypothetical components that simulate the TBP curve by a series of plateaus, and (2) the corresponding 19 mol percent points from the true boiling point curve. Both of these representations originate from a boiling point vs liquid volume distilled TBP assay with density vs boiling point data in addition. The latter were required in converting from liquid volume to mol percent distilled.

Usually the TBP curve is given as boiling point temperatures at even percent distilled intervals. For the present purposes it is more convenient to use the TBP points that correspond to the plateaus even though the mol percent values are of odd values. From the standpoint of the integral method, the TBP points may be at any intervals, assorted or otherwise.

Vapor pressures are given in Table 16.1 for these 19 TBP points, or hypothetical components, at four temperatures. For these calculations, the vapor-liquid K values will be taken as the ratio of vapor pressure to total pressure, the latter being 760 mm Hg.

These 19 components were combined into two, three, four and five component groups to give 11, 9, 8 and 4

TABLE 16.2—Effect of Number of Hypothetical Components in Petroleum Fraction Breakdown On Equilibrium Flash Vaporization Accuracy

Flash Temperature °F	Mixture Representation Number of Components	Equilibrium V/L
322	8	1.9
	11	1.87
	19	1.84
	∞	1.80
355	19	3.84
	∞	3.70
365	4	11.85
	9	6.64
	19	5.75
	∞	5.65

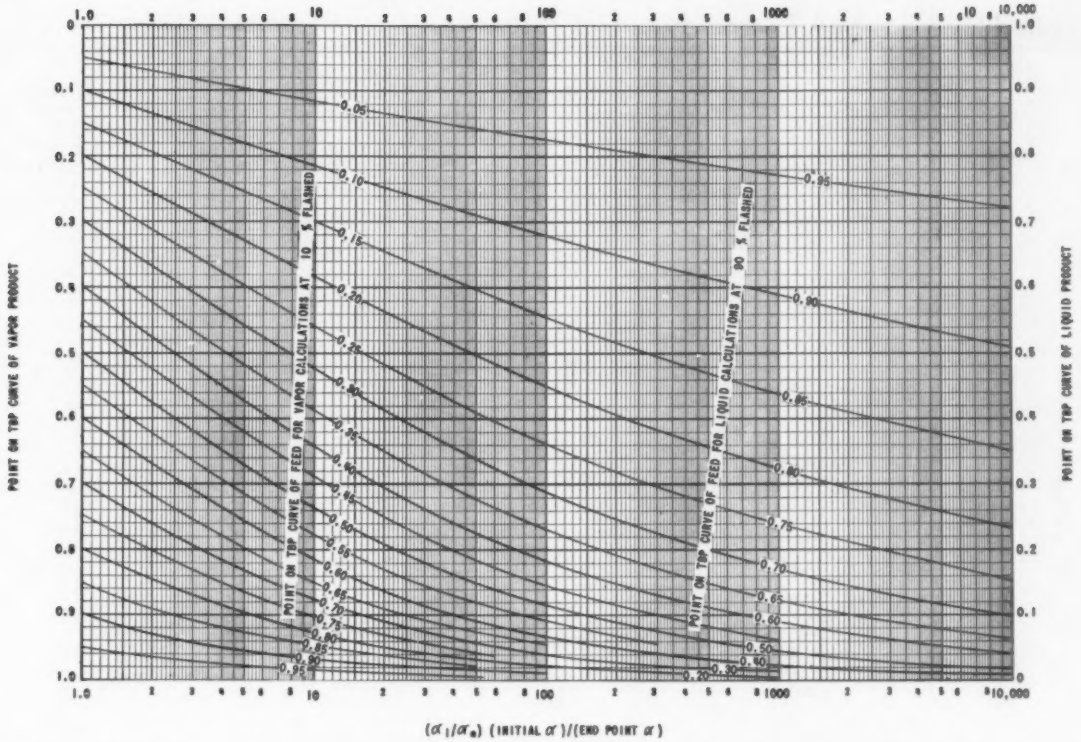

POINT ON TBP CURVE OF VAPOR PRODUCT
POINT ON TBP CURVE OF LIQUID PRODUCT
POINT ON TBP CURVE OF FEED FOR VAPOR CALCULATIONS AT 10 % FLASHED
POINT ON TBP CURVE OF FEED FOR LIQUID CALCULATIONS AT 90 % FLASHED
(α1/αe) (INITIAL α)/(END POINT α)

FIGURE 16.2—TBP curves of equilibrium vapor at 10 percent flashed and of equilibrium liquid at 90 percent flashed.

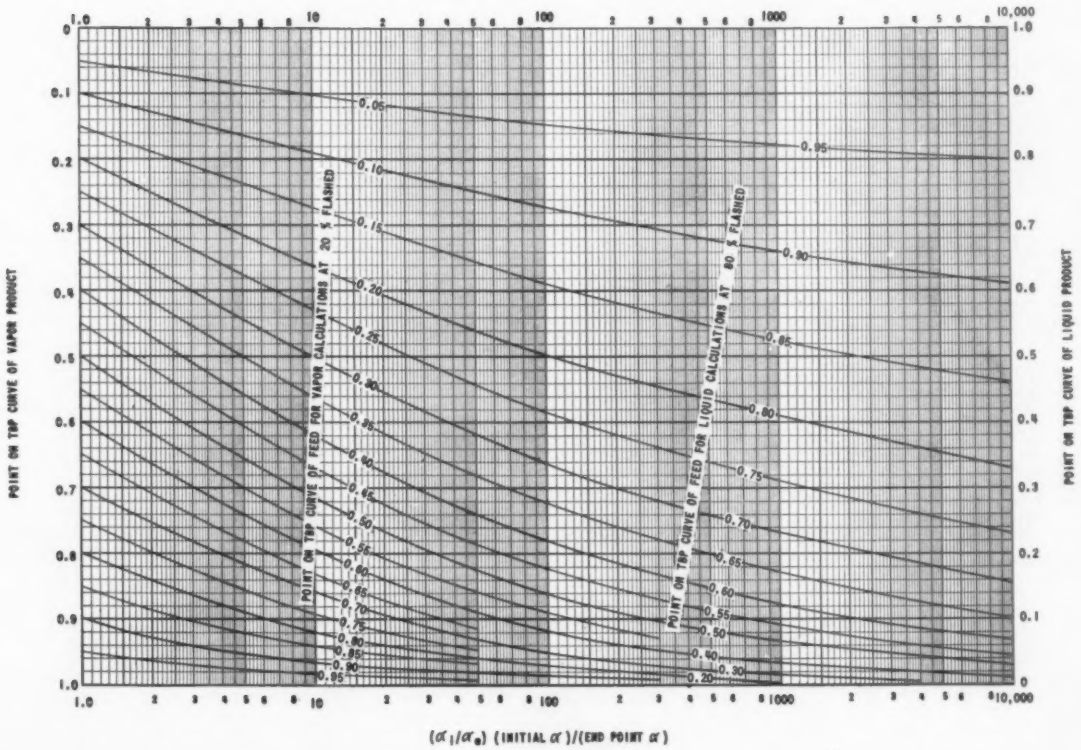

POINT ON TBP CURVE OF VAPOR PRODUCT
POINT ON TBP CURVE OF LIQUID PRODUCT
POINT ON TBP CURVE OF FEED FOR VAPOR CALCULATIONS AT 20 % FLASHED
POINT ON TBP CURVE OF FEED FOR LIQUID CALCULATIONS AT 80 % FLASHED
(α1/αe) (INITIAL α)/(END POINT α)

FIGURE 16.3—TBP curves of equilibrium vapor at 20 percent flashed and of equilibrium liquid at 80 percent flashed.

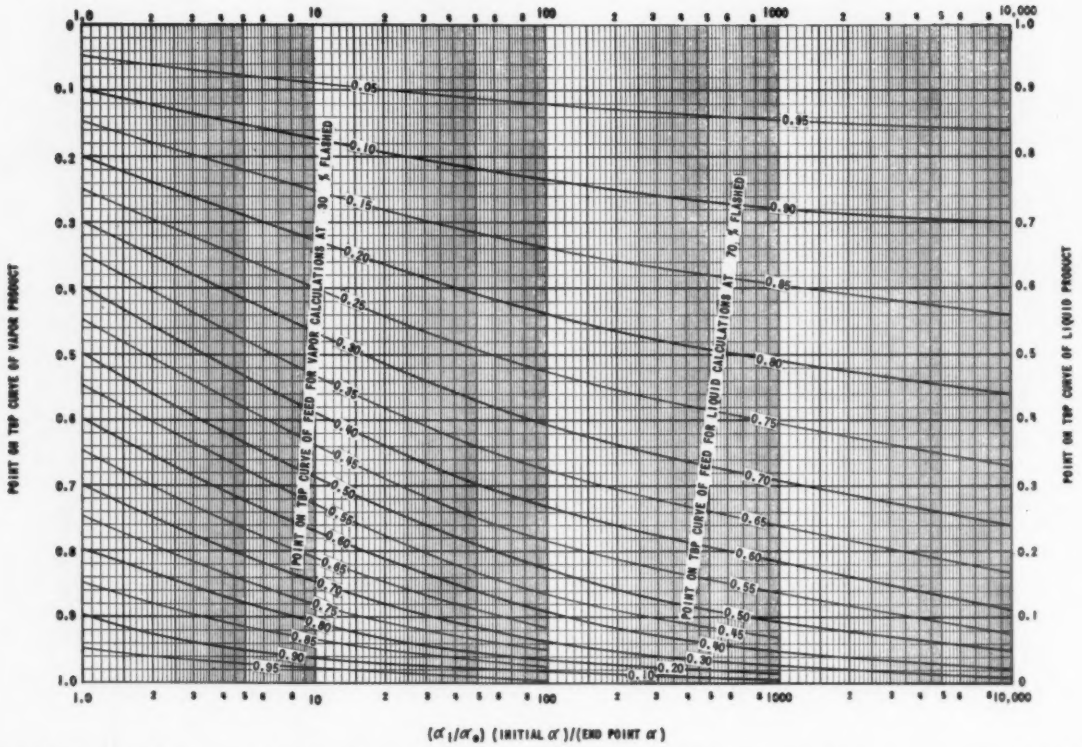

POINT ON TBP CURVE OF VAPOR PRODUCT
POINT ON TBP CURVE OF LIQUID PRODUCT
POINT ON TBP CURVE OF FEED FOR VAPOR CALCULATIONS AT 30 % FLASHED
POINT ON TBP CURVE OF FEED FOR LIQUID CALCULATIONS AT 70 % FLASHED
(α_1/α_e) (INITIAL α)/(END POINT α)

FIGURE 16.4—TBP curves of equilibrium vapor at 30 percent flashed and of equilibrium liquid at 70 percent flashed.

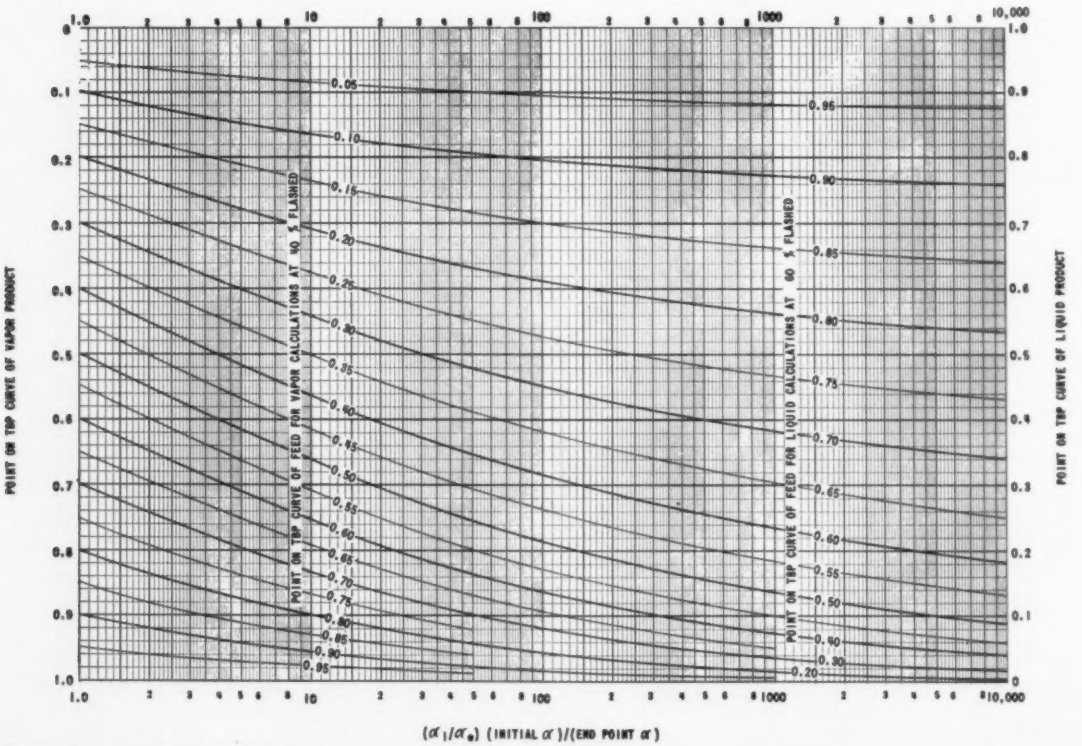

POINT ON TBP CURVE OF VAPOR PRODUCT
POINT ON TBP CURVE OF LIQUID PRODUCT
POINT ON TBP CURVE OF FEED FOR VAPOR CALCULATIONS AT 40 % FLASHED
POINT ON TBP CURVE OF FEED FOR LIQUID CALCULATIONS AT 60 % FLASHED
(α_1/α_e) (INITIAL α)/(END POINT α)

FIGURE 16.5—TBP curves of equilibrium vapor at 40 percent flashed and of equilibrium liquid at 60 percent flashed.

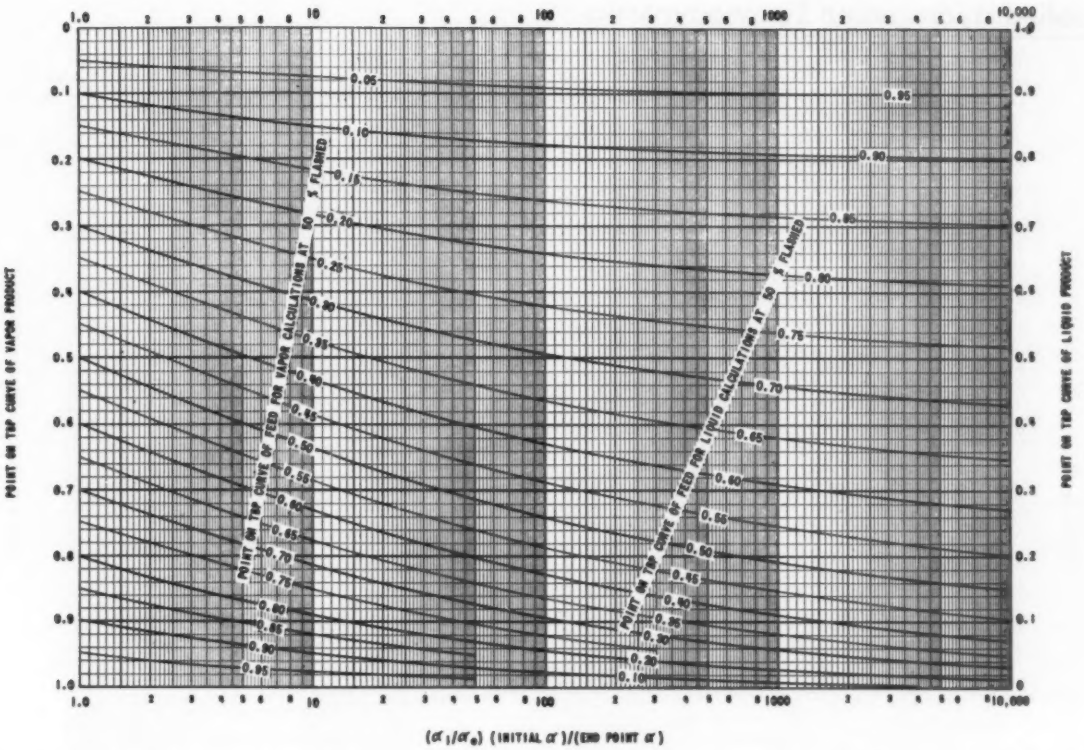

POINT ON TBP CURVE OF VAPOR PRODUCT
POINT ON TBP CURVE OF LIQUID PRODUCT
POINT ON TBP CURVE OF FEED FOR VAPOR CALCULATIONS AT 50 % FLASHED
POINT ON TBP CURVE OF FEED FOR LIQUID CALCULATIONS AT 50 % FLASHED
(α1/αe) (INITIAL α)/(END POINT α)

FIGURE 16.6—TBP curves of equilibrium vapor at 50 percent flashed and of equilibrium liquid at 50 percent flashed.

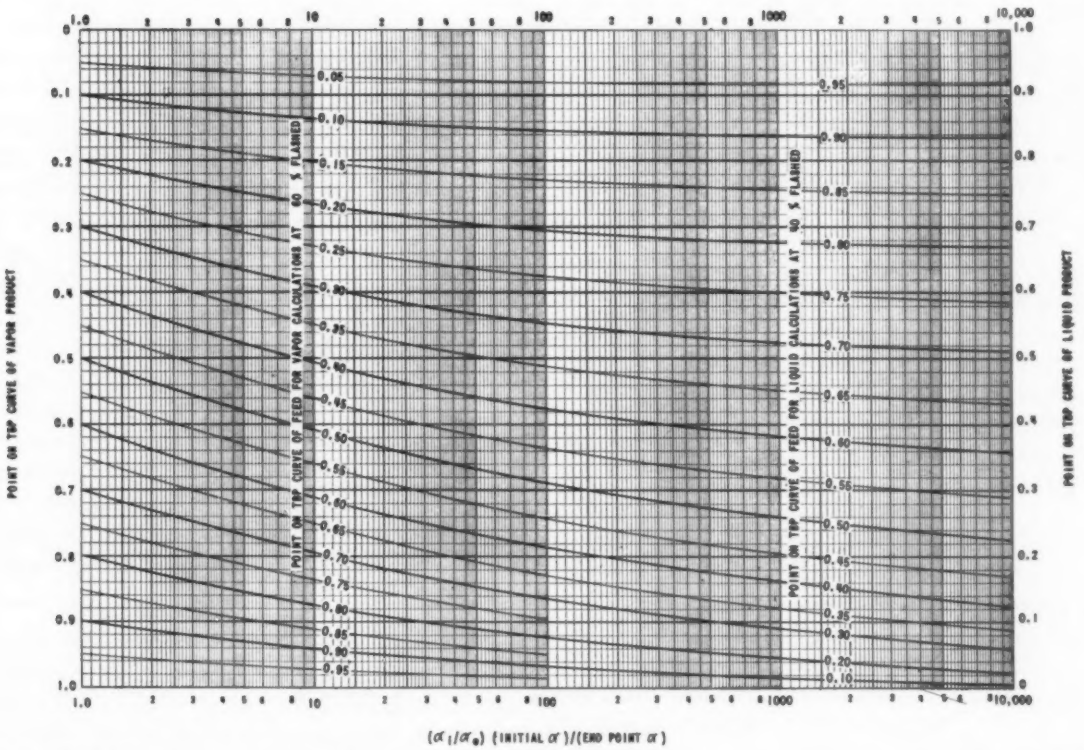

POINT ON TBP CURVE OF VAPOR PRODUCT
POINT ON TBP CURVE OF LIQUID PRODUCT
POINT ON TBP CURVE OF FEED FOR VAPOR CALCULATIONS AT 60 % FLASHED
POINT ON TBP CURVE OF FEED FOR LIQUID CALCULATIONS AT 40 % FLASHED
(α1/αe) (INITIAL α)/(END POINT α)

FIGURE 16.7—TBP curves of equilibrium vapor at 60 percent flashed and of equilibrium liquid at 40 percent flashed.

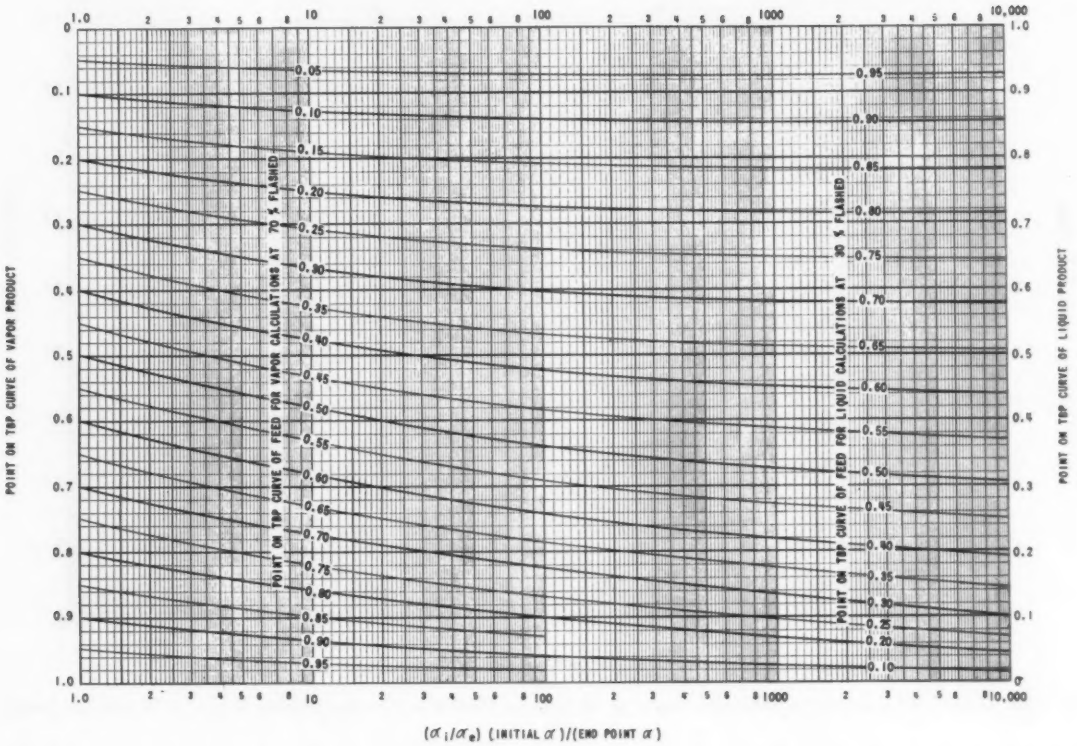

POINT ON TBP CURVE OF VAPOR PRODUCT
POINT ON TBP CURVE OF FEED FOR VAPOR CALCULATIONS AT 70 % FLASHED
POINT ON TBP CURVE OF FEED FOR LIQUID CALCULATIONS AT 30 % FLASHED
POINT ON TBP CURVE OF LIQUID PRODUCT
(α_1/α_e) (INITIAL α)/(END POINT α)

FIGURE 16.8—TBP curves of equilibrium vapor at 70 percent flashed and of equilibrium liquid at 30 percent flashed.

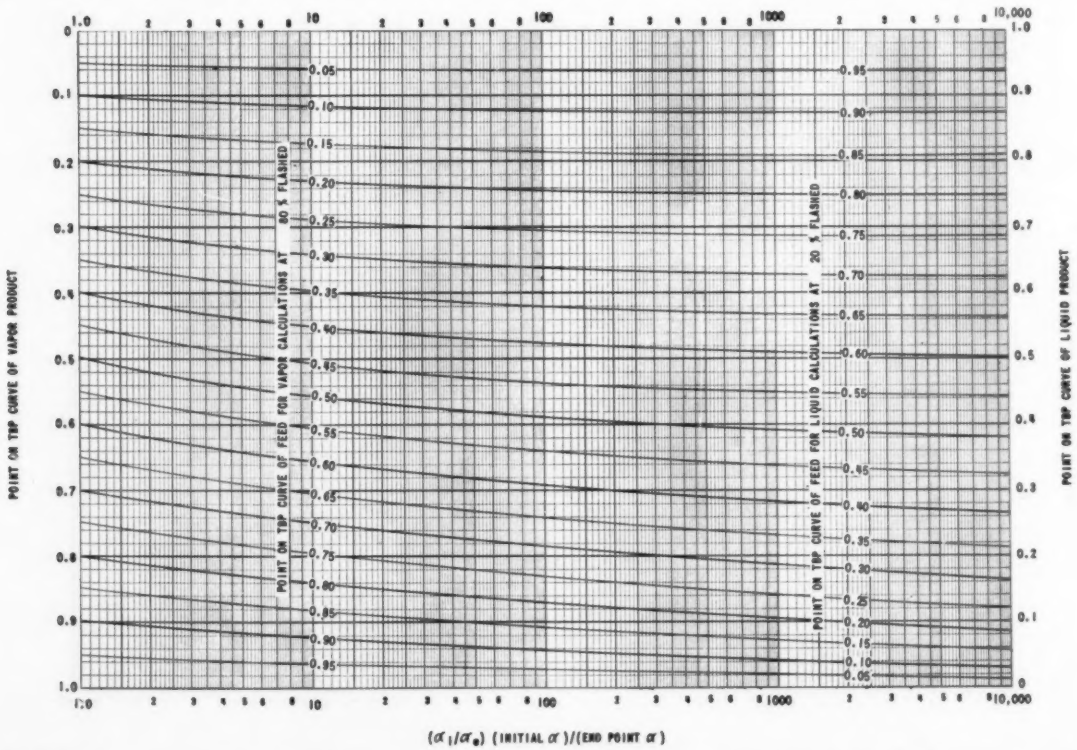

POINT ON TBP CURVE OF VAPOR PRODUCT
POINT ON TBP CURVE OF FEED FOR VAPOR CALCULATIONS AT 80 % FLASHED
POINT ON TBP CURVE OF FEED FOR LIQUID CALCULATIONS AT 20 % FLASHED
POINT ON TBP CURVE OF LIQUID PRODUCT
(α_1/α_e) (INITIAL α)/(END POINT α)

FIGURE 16.9—TBP curves of equilibrium vapor at 80 percent flashed and of equilibrium liquid at 20 percent flashed.

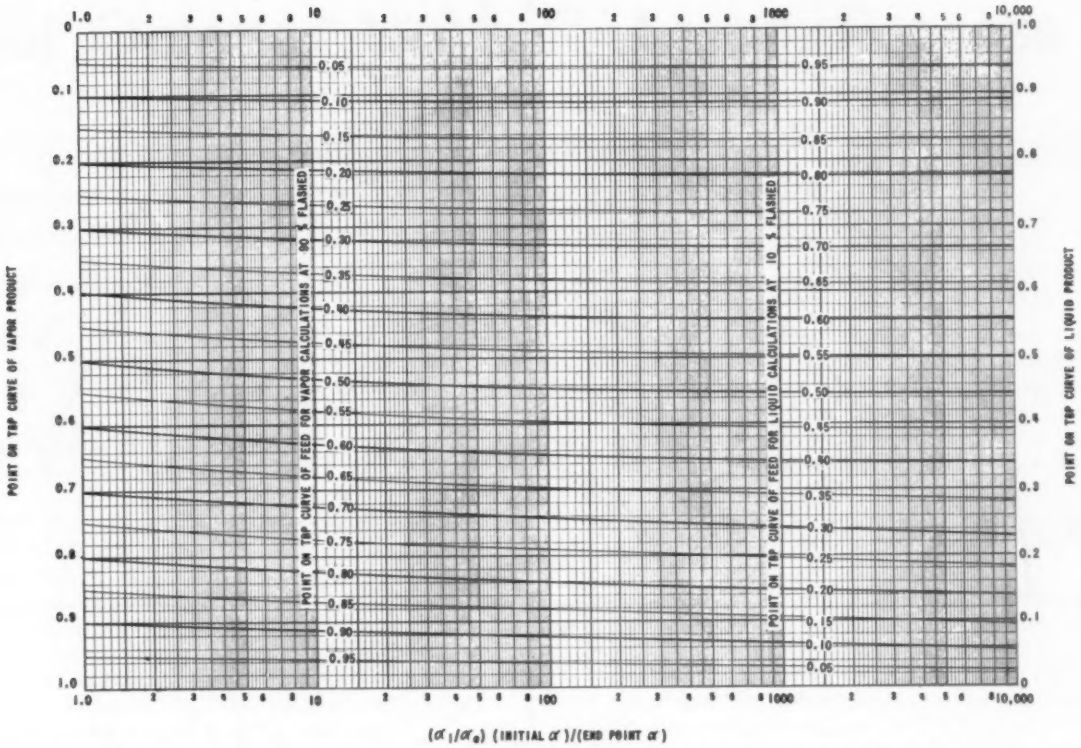

POINT ON TBP CURVE OF VAPOR PRODUCT
POINT ON TBP CURVE OF FEED FOR VAPOR CALCULATIONS AT 90 % FLASHED
POINT ON TBP CURVE OF FEED FOR LIQUID CALCULATIONS AT 10 % FLASHED
POINT ON TBP CURVE OF LIQUID PRODUCT
(α_i/α_e) (INITIAL α)/(END POINT α)

FIGURE 16.10—TBP curves of equilibrium vapor at 90 percent flashed and of equilibrium liquid at 10 percent flashed.

component representations of the naphtha for some of the calculations. Molar average vapor pressures were used in finding the K values for each of these larger hypothetical components.

With these data, equilibrium flash vaporization calculations were made for this petroleum naphtha at atmospheric pressure and three temperatures (322, 355, and 365° F). The values of V/L that satisfy equilibrium for each mixture representation were found by successive approximation.

The integral type calculations for an infinite component representation were made in the manner illustrated by Example 1 of Part 14, using Equations 14.4 and 14.5. The finite component calculations were also made with these same equations and the same K values. The difference between these two calculations is that the v/f ratios were integrated over the entire composition range in the integral method to get V/F and then V/L, while in the finite component method, summations were used to give $(V/L) = \frac{\Sigma v}{(F - \Sigma v)}$.

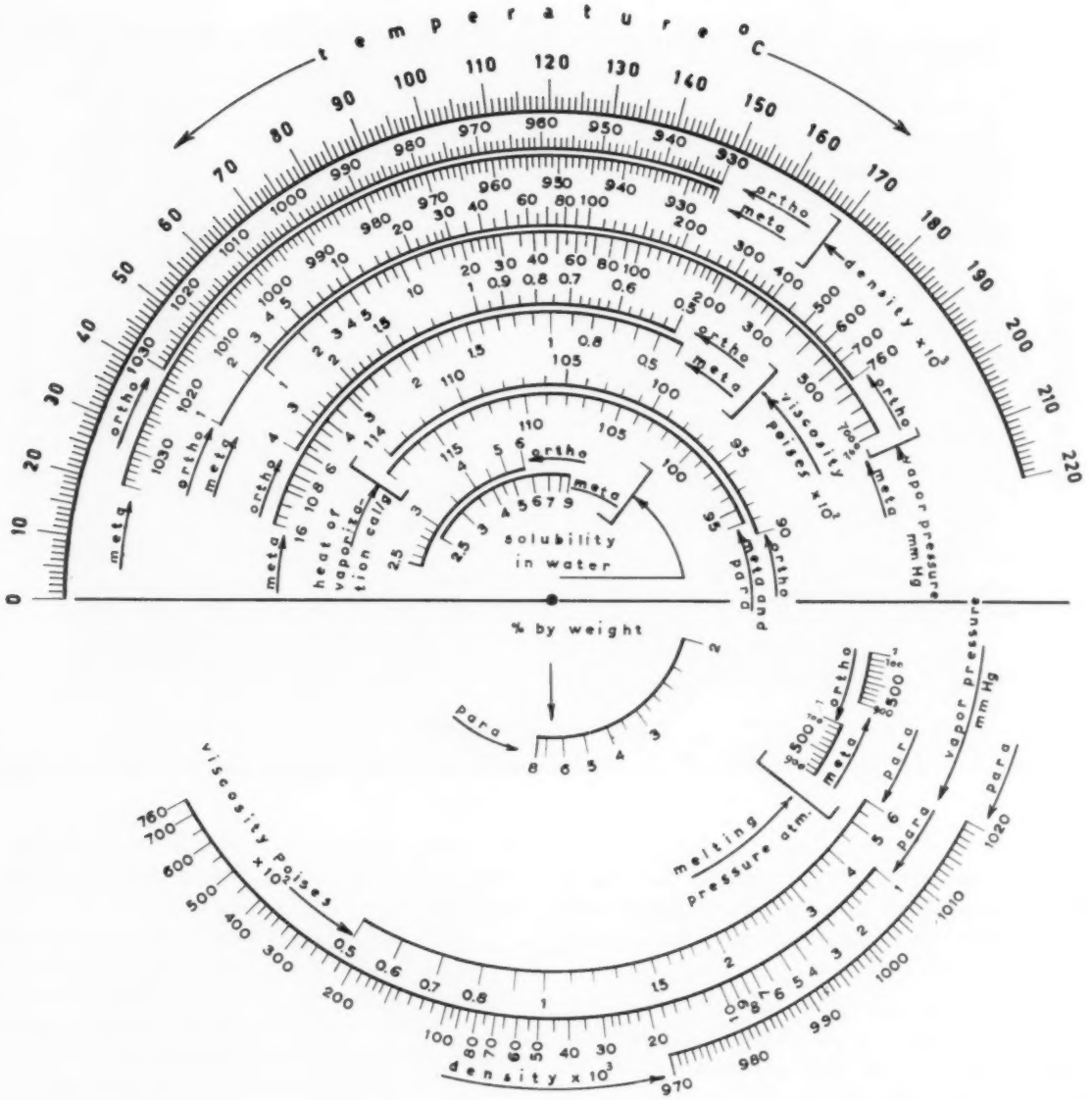
In the results of these calculations, which are given in Table 16.2, a significant effect of the number of components on the equilibrium (V/L) ratio is indicted. The values of V/L for ∞ components are assumed to be correct. As would be expected, the fewer components in the mixture representation, the greater the deviation from the correct value of V/L.

It will be noted that these deviations are all positive, i.e., the $(V/L)_n > (V/L)\ \infty$ and that the V/L values are all greater than unity, i.e., $V > L$. When $V < L$ or $V/L < 1.0$ the deviations of the finite component breakdowns are in the other direction, i.e., $(V/L)_n < (V/L)\ \infty$, but $(V/L)\ \infty$ will be the correct ratio.

TBP Transformation Charts. Ten new charts (Figures 16.1 through 16.10) have been prepared for estimating the true boiling point assays of equilibrium vapor and liquids from flash vaporization of petroleum fractions. In these new charts, a point on the TBP of the vapor product (or liquid product) is a function of: (1) the corresponding (i.e., same TBP temperature) point on the TBP of the feed, (2) the ratio (α_i/α_e) and (3) the amount of the feed that is flashed vaporized.

These are the same variables used in the TBP transformation correlations, Figures 15.1 through 15.4, which were derived from the same equations but arranged differently. The earlier charts are more convenient for interpolating to intermediate percents flashed while these new charts are easier to read at uneven values of (α_i/α_e) the ratio of terminal relative volatilities.

TO BE CONTINUED



Physical Properties of Liquid Cresoles

A. M. P. Tans, Staatsmijnen in Limburg
Geleen, Netherlands

THIS NOMOGRAPH combines the most important physical properties of the three liquid isomeric cresoles. The nomograph has been constructed from literature values.

The upper part of the nomograph gives the properties of *o*-cresole and *m*-cresole; the lower part gives the properties of *p*-cresole and the melting pressure of *o*-, and *p*-cresole. The change in melting point with increase in pressure is read from the nomograph, e.g. at a pressure of 500 atm. the melting point of *o*-cresole is about 38.5° C.

With respect to the heat of vaporization the same scale holds for both the *m*- and the *p*-isomer; the heats of vaporization were calculated from the vapor pressures.[1] For the solubility the data of Michels and ten Haaf[2] were taken from Seidell.[3] Older values given by Seidell are not in good agreement with these values.

In the use of the nomograph the temperature scale holds for any property, so that any line passing through the center intersects the scales in corresponding points.

LITERATURE CITED

[1] Pardee, W. A., and Weinrich, W. Ind. Eng. Chem., 36, 595 (1944).
[2] Michels, A., and ten Haaf, E. C. F. Proc. Akad. sci. (Amsterdam), 30, 52 (1957).
[3] Seidell, A. "Solubilities of Organic Compounds," Vol. 2, 3rd. ed., 1941.

Get Octanes With This Isom Process

The Iso-Kel process gets a thorough examination in a small scale isothermal test unit. See what isomerization of light straight run material will do

W. H. Decker, Sinclair Research Laboratories, Inc., Harvey, Ill.

THE ISO-KEL PROCESS is intended specifically to isomerize the pentane and hexane portions of a gasoline blend. Thus the process offers the refiner another way to keep up with the increasing octanes—by upgrading the light straight run component of the motor gasoline pool.

The catalyst development for the process involved first a program to formulate a suitable catalyst type, and second a testing study of the selected catalyst under a range of conditions with various feedstocks. This article reports the techniques used in the Sinclair Research Laboratories to develop process information with a typical light naphtha.

The Iso-Kel Process. The Iso-Kel process was developed by The M. W. Kellogg Company with Engelhard Industries and Sinclair Research Laboratories aiding in the production of the catalyst. Originally announced in February, 1957,[1] the process was discussed in detail at the 1957 Mid-Year Meeting of the American Petroleum Institute.[2]

The essential basis of the process involved the formulation of a new catalyst by the M. W. Kellogg Company. In the form of a $\frac{1}{16}$-inch extrudate and employing a precious metal other than platinum, the catalyst embodies the following performance characteristics:

- High selectivity.
- High conversion.
- Excellent maintenance of activity without need for periodic regeneration.
- Ability to be regenerated in the event of deactivation from operational upsets, so that virgin or near virgin activities may be maintained over the life of the catalyst.
- Simple regeneration technique not requiring special equipment.
- Satisfactory resistance to poisoning effects of typical light naphtha metal contaminants.

An experimental program established the operating conditions for the process. The probable ranges of the major process variables are as follows:

Temperature, F	700- 800
Pressure, psig	100- 750
Recycle Gas Rate, cu ft/bbl	1500-6000
Space Velocity, wt/(hr) (wt cat)	1- 10

The selection of the type of processing system must be based upon properties of both the feedstock and the desired product. With the equilibrium considerations which will be discussed later, together with the boiling point characteristics of the pentane and hexane fractions, it is usually more desirable to have a process system consisting of recycle operations of the pentanes and once-through operation of the hexanes. This type of operation is shown in Figure 1 which is a schematic flow diagram of a typical process system.

The pentane-hexane feed is charged to a deisopentanizer for removal of the isopentane. The bottoms from the deisopentanizer is mixed with hydrogen-rich recycle gas before being charged to the heater-reactor system. From the reactor the effluent flows to a separator from which the gas stream is recycled to the inlet system in order to maintain a hydrogen atmosphere. The liquid from the separator flows to a debutanizer and then to a depentanizer. Overhead from the depentanizer is recycled to the deisopentanizer while the column bottoms is sent directly to gasoline blending. A small make-up hydrogen stream is required because of the small hydrogen consumption resulting from hydrocracking.

An analysis of equilibria of the several systems will illustrate the factors to consider in choosing the best processing scheme. For example, the conversion of the normal pentane to isopentane is limited by the thermodynamic equilibrium to between 65 and 70 percent for the general range of conditions employed in this proc-

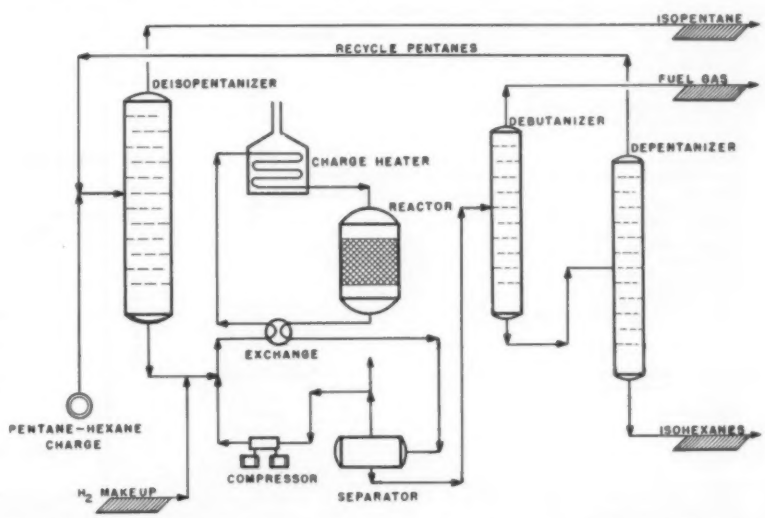


FIGURE 1—The Iso-Kel process offers a way to upgrade the light straight run component of the motor gasoline pool.

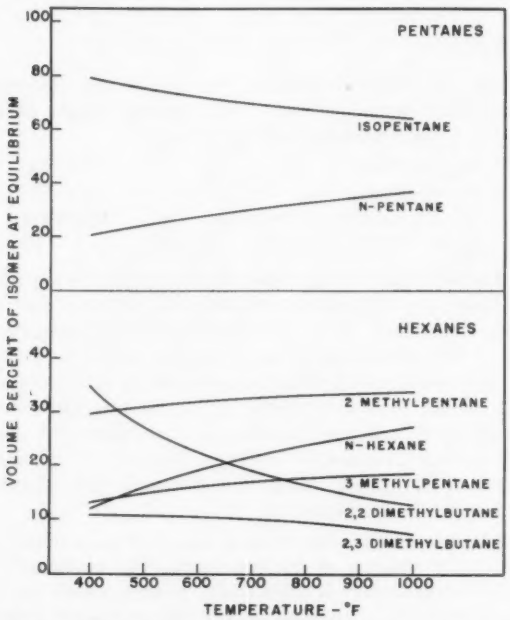


FIGURE 2—The thermodynamic equilibrium limits the conversion of the various components.

ess. As a consequence it would be desirable normally to limit the conversion per pass to about 60 percent since cracking reactions tend to increase with the approach to thermodynamic equilibrium.

With normal hexane the conversion per pass would be higher than with normal pentane since the thermodynamic equilibrium is approximately 76 to 79 percent at these conditions. Figure 2 is a plot of the equilibrium composition of the pentanes and hexanes over the range of 400 to 1,000 F.[3]

Because of the relatively close boiling points of the various components in the hexane range, it is usually more economical to process the hexanes on a once-through basis. This would be true particularly in those cases where the methylcyclopentane content of the feedstock is high, since separation of methylcyclopentane from hexane by distillation is difficult and the corresponding recycle rate would be high. Furthermore, the thermodynamic equilibrium limits the conversion of methylcyclopentane to cyclohexane to approximately 12 percent whereas the isomerization of normal hexane is approximately 77 percent.

If however, the isohexane content of the feed is relatively high then it would be desirable to provide a deisohexanizing column and recycle the normal hexane to extinction. With such an operation three product streams are produced—an isopentane concentrate, virgin isohexanes, and an isohexane concentrate. The selection of the specific system to be employed for a given installation is therefore largely governed by the feedstock quality. A previous article[2] has discussed the products to be expected from the Iso-Kel process for four typical feedstocks.

TABLE 1—Demonstration Run Feedstock Analysis

Component	Volume Percent
Isopentane	2.72
N-Pentane	31.15
Cyclopentane	1.90
2, 2 Dimethylbutane	0.84
2, 3 Dimethylbutane	2.29
2-Methylpentane	14.14
3-Methylpentane	10.52
N-Hexane	21.88
Methylcyclopentane	5.17
Benzene	0.59
Cyclohexane	2.69
Dimethylpentanes	1.12
Dimethylcyclopentanes	1.04
Methylhexanes	3.29
N Heptane	0.38
Methylcyclohexane	0.15
Ethylcyclopentane	0.01
Dimethylhexanes	0.04
1, 2, 3,—Trimethylcyclopentane	0.08
Total	100.00
Summary Analysis	**Volume Percent**
Paraffins	53.41
Isoparaffins	34.96
Naphthenes	11.04
Aromatics	0.59
	Octane Numbers
Motor (ASTM D357) Without TEL	63.2
With 3cc TEL/Gal	85.0
Reserch (ASTM D908) without TEL	63.0
With 3cc TEL/Gal	84.4

Process Commercialization. The formulation of a suitable catalyst and the associated process represents the initial phase of the over-all development of a commercially acceptable process. It is also necessary to prepare an adequate demonstration of the performance of the catalyst under the anticipated commercial conditions. Such a demonstration usually implies the design and operation of a prototype pilot plant. However, in this case it was elected to use a small bench scale isothermal reactor system, containing about 100 grams of catalyst, to simulate commercial operations. With such equipment this study could be carried out with minimum expense and would be essentially comparable to commercial operations except for the use of integrated fractionation facilities.

A light straight-run naphtha with inspections as

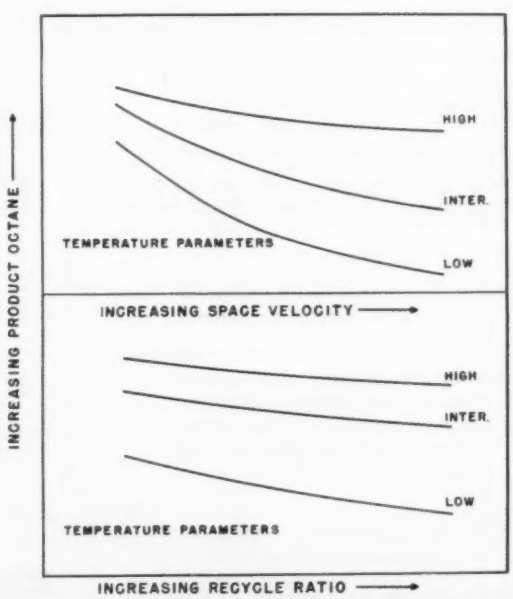


FIGURE 3—Increasing either the space velocity or the recycle ratio will give a lower product octane.

shown in Table 1 was selected for this particular program. The component analysis of the naphtha would indicate recycle pentane and once-through hexane processing would represent a suitable operation. The feedstock, as prepared by fractionation of raw crude, has a ratio of iso to normal pentane that would not be representative of the ratio resulting from operation of a recycle deisopentanizer as shown in Figure 1. It was therefore necessary to add sufficient normal pentane to the mixture in order to simulate the operation of the deisopentanizer column. The analysis shown in Table 1 represents the feedstock after the addition of n-pentane.

This processing system avoids the necessity for the operation of a recycle fractionation system in conjunction with the reactor system, however, this would not be considered objectionable since the design and operation of fractionation equipment is well known.

The demonstration test run involved three phases:

- Study of process variables
- Study of aging characteristics
- Study of regenerability.

The first phase was intended to develop the major process variables so that a suitable basis would be available for the selection of the optimum process design. The study, however, included only the variables of temperature, space velocity, and recycle ratio with the pressure fixed at a constant value of 600 psig. This was done inasmuch as the extensive earlier exploratory studies had indicated this pressure was the most suitable for this particular feedstock.

The actual test program involved a total of fifteen individual tests, run in duplicate, developed on a minimum point program basis so that every possible combination of each variable would not have to be tested. Intermediate activity tests, with fixed conditions, were made during the program to be certain no loss in the activity of the catalyst occurred. The results of the process variable study are presented in Figures 3 and 4.

The weight hourly space velocity and gas recycle ratio influence the product octane for the several temperature levels as shown in Figure 3. An increase in the space velocity, i.e., lowering of processing severity, will reduce the final product octane with the effect being more pronounced at the lower temperatures than at the higher temperatures. The same situation exists with respect to an increase in the gas recycle ratio.

The C_5-EP liquid yield is given in Figure 4 versus the product Research octane with 3cc of TEL for three temperature levels. From here it is evident that reducing the processing temperature will reduce the undesirable cracking side reactions to butane and lighter components and therefore improve the final yields. An analysis then of these data will permit an optimization of the several process variables for any particular feedstocks.

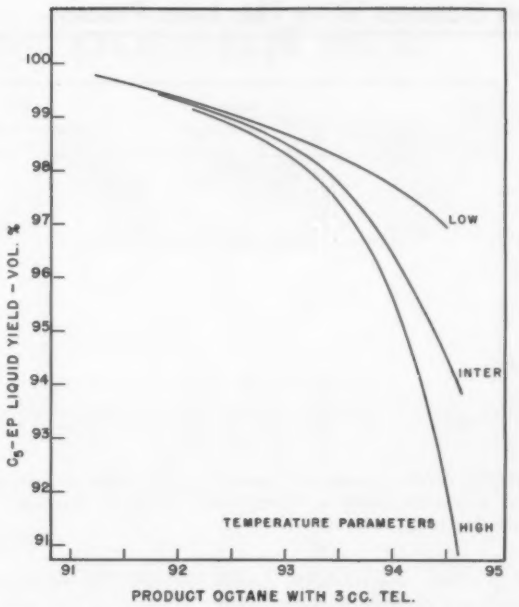


FIGURE 4—Reducing the processing temperature reduces the undesirable side reactions of cracking to lighter components.

An aging run was carried out for a period of 1830 hours, representing an accumulated catalyst life of 25 barrels per pound of catalyst. Figure 5 is a plot of the C_5-EP liquid yield and the C_5-EP Research octane with 3 cc TEL per gal. for the entire demonstration test run. During this period there was a slight decline in the activity of the catalyst. This would however, not be considered significant inasmuch as during normal commercial operations a decline of this magniture would be compensated for by slight increases in the processing temperature during the cycle. Detailed inspections of

TABLE 2—Component Analysis of Typical Liquid Product Aging Run

Component	Volume Percent
Isopentane	32.00
N-Pentane	1.68
Cyclopentane	1.83
2, 2—Dimethylbutane	3.75
2, 3—Dimethylbutane	3.54
2—Methylpentane	16.23
3—Methylpentane	11.67
N-Hexane	15.61
Methylcyclopentane	7.42
Benzene	0.13
Cyclohexane	1.00
Dimethylpentanes	0.89
Dimethylcyclopentanes	0.75
Methylhexanes	2.36
N-Heptane	0.64
Methylcyclohexane	0.24
Ethylcyclopentane	0.11
Dimethylhexanes	.....
1, 2, 3—Trimethylcyclopentane	0.01
Toluene	0.14
Total	100.000

TABLE 3—Summary of Feed and Product Inspections

Summary Analysis	PERCENT BY VOLUME	
	Feed	Product
Pentanes		
Paraffins	31.15	1.68
Isoparaffins	2.72	32.00
Naphthenes	1.90	1.83
Hexanes:		
Paraffins	21.88	15.61
Isoparaffins	27.79	35.19
Naphthenes	7.86	8.42
Aromatics	0.59	0.13
Heptanes:		
Paraffins	0.38	0.64
Isoparaffins	4.41	3.25
Naphthenes	1.20	1.10
Aromatics	.....	0.14
Octanes:		
Paraffins	.....	.....
Isoparaffins	0.04	.....
Naphthenes	0.08	0.01
Total	100.00	100.00

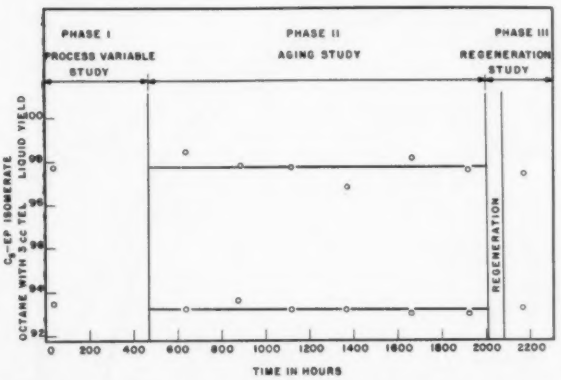


FIGURE 5—In commercial operations, the slight decline in catalyst activity would be compensated for by an increase in processing temperature.

the product distributions during the run indicated no significant change had occurred.

In Table 2 a component analysis of the product from this aging run is presented, while Table 3 presents a summarized analysis of both the feed and products for this operation. It will be seen from this summary that even though the amount of the C_7 paraffins was reduced there was an increase in the amount of normal heptane in the isomerized product. This would indicate that some fraction of the isoheptanes had been converted to normal heptane, a condition resulting from the fact that the isoheptane-normal heptane ratio is higher in the feedstock than the equilibrium amount at these test conditions. This is substantiated when it is considered that the normal heptane has a higher boiling point than the isoheptanes and therefore fractionation of a normal light naphtha fraction will produce a fraction high in isoheptanes. Because of this factor and the relative ease of cracking of the heptanes it would be desirable to minimize as much as possible the amounts of heptanes in the isomerization system feedstocks.

The regenerability of the catalyst was studied next. Such information is of importance since a suitable regeneration technique would permit the maintenance of virgin or near virgin activity and selectivity over the life of the catalyst. Thus deactivation of the catalyst either as the result of extended periods of processing or as the result of operational mishap could be compensated for by regeneration.

For this test run operation there had been no significant degree of deactivation and it was therefore elected to simulate one possible commercial unit operating difficulty. This was accomplished by reducing the recycle gas flow to zero i.e., recycle gas compressor failure, while maintaining all other conditions constant for a period of 15 hours. While it is realized that this is an extremely severe test it was believed that such a test would cause sufficient coke deposition on the catalyst to insure an adequate regeneration test. A standard activity test following this treatment indicated that essentially complete deactivation of the catalyst had been accomplished. The catalyst was then subjected to a regeneration treatment.

From Figure 5 it will be seen that the regeneration treatment was satisfactory inasmuch as the activity of the regenerated catalyst was substantially equivalent to the virgin activity. Following this regeneration study the normal aging run was resumed and continued for an additional period of about 200 hours. At this point in the study a total of 31 barrels of feed per pound of catalyst had been processed and it was elected to terminate the test. The stability of the catalyst both with respect to activity and selectivity was such that additional process studies did not appear to be warranted.

Supporting Studies. There are a number of supporting studies which are necessarily involved at various stages in a process development such as this. These are summarized briefly as follows:

Feedstock quality with respect to probable contaminants is of primary importance in the development of a suitable catalyst. Thus, an extensive investigation was made of the effect of probable catalyst poisons. Included were studies involving the effect of water, sulfur, lead, arsenic, and other metal contaminants. It was found that the usual hydrodesulfurization pretreatment reduced objectionable sulfur contents and contaminants if present to a suitable level.

Gasoline blending and road testing programs were carried out extensively to evaluate the effect of addition of isopentane-isohexane concentrates on finished gasoline quality and performance. While a complete review of this work is beyond the scope of this discussion it may be stated that these isomerized liquids have a significant contribution to improved road performance.

Process economics and the engineering design of the equipment required were studied in detail so that a basis would be available for an over-all evaluation of the process. While the results of such studies cannot be presented here it has been developed that this process is economically competitive with existing octane improvement processes and will require serious consideration in the production of high performance motor fuels.

ACKNOWLEDGMENT

The author wishes to acknowledge the permission of The M. W. Kellogg Company, and the Sinclair Research Laboratories for the publication of this information.

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About the Author

W. H. Decker is technical assistant to the Manager of the Process Division for Sinclair Research Laboratories, Inc., Harvey, Ill. Working on research and development of isomerization and catalytic reforming since 1952, he has in the past done equipment design and combustion engineering for Sinclair Refining Company. He holds a B.S. degree in chemical engineering from University of Colorado.

Why I-R process pumps are

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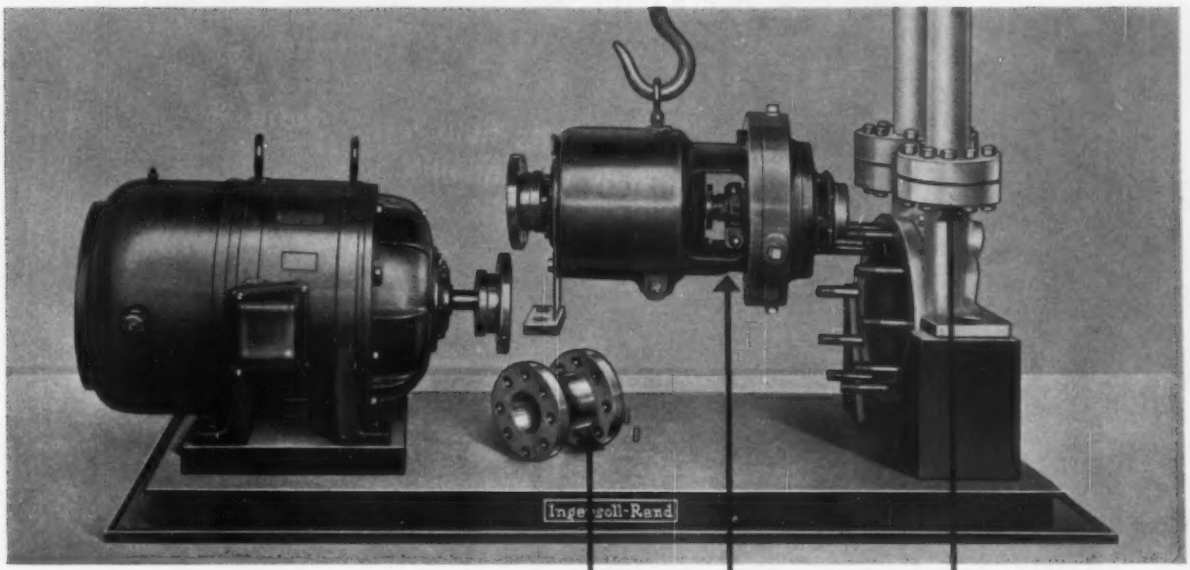

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Fire Safety Economics: Part 2

5 Safer Methods of Chemical Storage

Here's a valuable fire safety rating chart which enables you to compare the different types of storage tanks. There's also some good advice on fire extinguishing techniques and materials.

James J. Duggan

Union Carbide Chemicals Co.
South Charleston, W. Va.

THE FIRE Protection Engineering groups of Union Carbide Chemicals Co. have a continuous program for fire protection in a chemical plant. Updated periodically by experience and research data, this program includes the storage and handling of flammable liquids as topics of primary concern. Investigation has shown that there are safer and more efficient ways of storing flammable liquids than with an API 12C cone roof storage tank. Most of these improved methods have been applied to a degree in the petroleum industry, however, most vapor conservation type tankage as now designed is not readily adaptable to general chemical storage.

Frequent interchange of service, corrosion, and the detrimental effect of liquid or vapor exposure to diaphragms, gaskets, etc., or, conversely, the detrimental effect of such tank appurtenances on product purity, are among the problems to be overcome.

At least five improved methods for storing alcohol or other flammable or toxic liquids, each of which has its limitations have been found. However, there is application for each for improving fire safety, with vapor conservation, continuous production, and security of equipment paying the bill and actually providing a return on the increased investment. Vapor conservation is particularly important where valuable products are involved. In

TABLE 1—Examples of Fire Safety Ratings, Conservation Type Tanks vs. Standard Cone Roof Tank

Type of Tank	RATING FACTOR					
	Susceptibility To Explosion	Susceptibility To Fire From Venting of Vapors	Susceptibility To Damage From Fire Exposure	Dependence On Fire-Fighting Efficiency	Dependence For Safety On Mechanical Appurtenances	Fire Safety Rating
Ideal Tank	20	20	20	20	20	100
Unprotected Cone Roof Tank	0	0	0	0	20	20
Standard Cone Roof Tank	5	5	5	5	15	35
Cone Roof Tank With Inert Gas & Water Cooling	20	10	15	10	5	60
Variable Vapor Space Tank With Inert Gas	20	10	10	10	10	60
Lifter Roof Tank	20	10	10	10	10	60
Low Pressure (2½ psi) Tank With Inert Gas	20	15	15	10	10	70
Noded Spheroid	20	15	15	10	10	70
Floating Roof Tank With Weather Shield	15	15	15	15	10	70
Floating Diaphragm Tank	15	20	10	10	20	75
Floating Roof Tank	20	15	20	20	10	85

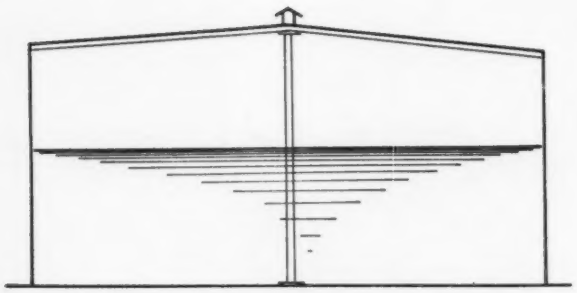


FIGURE 1—Unprotected cone roof tank.

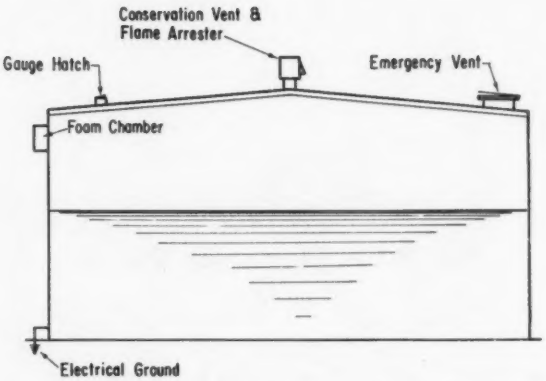


FIGURE 2—Standard cone roof tank.

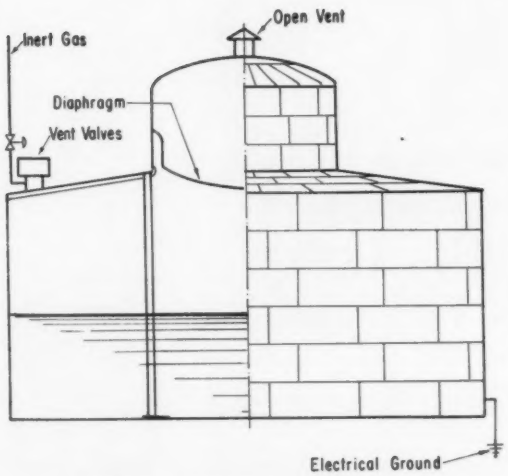


FIGURE 3—Variable vapor space tank.

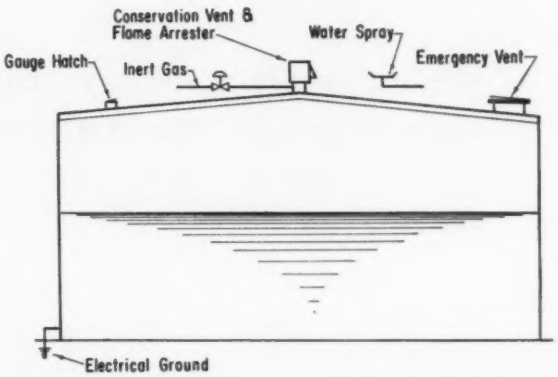


FIGURE 4—Cone roof tank with inert gas and water cooling.

general these improved methods include:

1. The use of an inert gas in the place of air in the vapor space of standard cone roof tanks in combination with a water spray or insulation would provide a means to minimize the effects of atmospheric temperature variations and maintain a more constant temperature in the vapor phase. These conditions will allow an increase in vapor conservation.

2. A variable vapor space tank also equipped with adequate inert gas protection.

3. The use of low pressure tanks (2½ psi maximum allowable working pressure) also equipped with inert gas protection.

4. A development utilizing a floating diaphragm within a tank wherein the product vapors are segregated from air.

5. The conventional floating roof tank which eliminates the large vapor space of the cone roof tank, thus providing effective vapor conservation and maximum fire safety of all storage methods considered.

COMPARATIVE SAFETY OF TANKS

For comparing the fire safety of different types of storage tanks, a special method of rating has been developed. This rating method takes into account five basic factors as shown in Table 1. These factors are entirely arbitrary and may or may not clearly define the degree of safety involved. However, they are a means of evaluating the different types of tanks to allow credit where fire safety is increased and impose a penalty where safety precautions are lacking.

All tank designs are compared in Table 1 with what we term an "Ideal Tank," wherein each of the five rating factors receives 20 points, or a total fire safety rating of 100.

Ideal Tank. Any description of an ideal tank would be highly controversial. However, to illustrate the point, the thinking is that an ideal tank would be a pressure vessel so designed as to eliminate all venting, thus containing completely the flammable compound, and be adequately spaced or otherwise protected to prevent exposure to fire. Such a tank would seem to be economically impractical, but it is used for rating purposes only.

In comparing the various tank designs with the ideal tank, each is penalized to the extent of the apparent existing safety problem.

Unprotected Cone Roof Tank. As an example, an unprotected cone roof tank (API 12C) (Figure 1), with inadequate vent devices, no flame arrester, and inadequate spacing, is given a fire safety rating of only 20. It is dependent for fire safety on its mechanical structure. All other factors have been violated. This is the lowest rating given any type of tank. Next lowest in safety rating is the standard cone roof tank shown in Figure 2.

Variable Vapor Space Tank. The variable vapor space tank with inert gas protection (Figure 3), the water cooled, inerted standard cone roof tank (Figure 4), and the lifter-roof tank (Figure 5) rate lower than the low-pressure tank because the possibility of fire from venting vapors is greater. The variable vapor space tank is considered more susceptible to damage by fire exposure, but less dependent on mechanical appurtenances than the standard cone roof tank with inert gas protection.

Low Pressure Tank. The low pressure tank equipped with inert gas protection is penalized only 5 points for venting. It is less susceptible to damage from fire exposure than the floating diaphragm tank, but is more dependent on mechanical appurtenances. This type of tank rates equally with the noded spheroid shown in Figure 6.

Floating Diaphragm Tank. The floating diaphragm tank rates high, as it eliminates practically all vapor losses and is reasonably independent of mechanical appurtenances for safety. It is penalized 5 points for the possibility of vapor leakage past the diaphragm, which could cause an explosive mixture in the vapor space. Ten points each are deducted because of susceptibility of the diaphragm to damage, and because fire fighting efficiency must be reasonably high to insure protection under fire exposure (Figure 7).

Floating Roof Tank. The floating roof tank has the highest fire safety rating due to the fact that the large majority of the safety deficiencies involving bulk storage have been eliminated. It is penalized only 5 points for venting or vapors which may escape around the seal and 10 points for increased maintenance and its dependence on maintaining a reasonably tight seal (Figure 8).

Summary of Tank Types. Figures 1 to 8 inclusive illustrate the types of tanks thus far discussed. Particular attention is directed to the low-pressure type of tank, the floating diaphragm tank, and the floating roof tank. These represent the logical types to consider for future construction, although many existing cone roof tanks may be converted to these types.

The arrangement illustrated in Figure 3 is possibly the most logical method of converting a standard cone roof tank to a fire-safe tank.

All these designs have been discussed with leading tank manufacturers and all are commercially available. It remains, however, for the individual user to determine his requirements and select the right type of storage for the product involved.

Improve Design. A study of this type provides data for improved design of tanks to accomplish increased fire safety, conservation of product, and continuous production. The designs discussed previously were brought about by this necessity for fire safety and conservation of product. In the future it is probable that design engineers may come up with different shapes that would be economical to fabricate and install, as well as to provide pressure storage; thus, increasing fire safety and security.

New designs being considered include tanks with smaller diameters and extending to heights of 60 to 100 feet. This approach allows standardization of tank sizes and shapes. Tall cylindrical vessels could be constructed by virtue of height. These tanks would be designed to possibly withstand two-and-one-half pounds pressure; thereby eliminating the necessity for inerting. The economy of this design would be in the possible utilization of standard shapes and shop fabrication. Table 2 summarizes graphically the comparative fire-safety ratings of different conservation and fire-safe types of tanks we have considered. Also, note specifically the example of annual gross savings that can be realized in the storage of ethyl alcohol under specifically engineered conditions. Savings through conservation methods are effected by many factors. However, a fire-safe tank will conserve product through decreased vaporization. The gross sav-

TABLE 2—Annual Gross Savings Possible From Improved Fire-Safe Tank Design

Type of Tank	Fire Safety Rating	Annual Gross Savings*
Ideal	100	$3,170
Floating Roof	85	2,560
Floating Diaphragm	75	3,050
Low Pressure—Inert Gas	70	3,000
Variable Vapor Space—Inert Gas	60	2,350
Std. Cone Roof—Inert Gas Water Spray	60	1,585
Standard Cone Roof	35	None
Unprotected Cone Roof	20	....

* Based on 60 ft. by 40 ft. ethyl alcohol tank averaging half full and turnover 12 tank volumes per year. Ethyl alcohol is priced at $0.56 per gallon. Increased investment, depreciation, and maintenance must be considered in determining net savings. Savings for other products are directly proportional to prices.

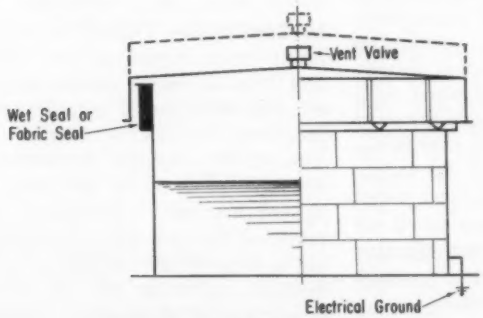


FIGURE 5—Lifter roof tank.

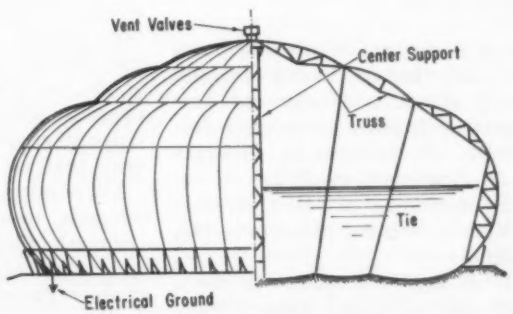


FIGURE 6—Noded spheroid.

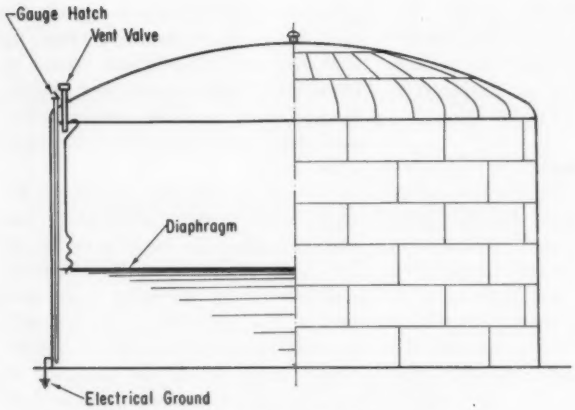


FIGURE 7—Floating diaphragm tank.

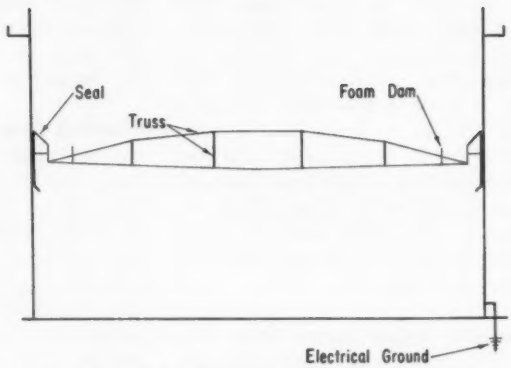


FIGURE 8—Pan type floating roof tank.

ings can be applied to amortize the increased cost and defray the increased depreciation and maintenance.

FIRE EXTINGUISHMENT

Every effort must be made to educate and train all people to have a safety consciousness. But if fires do occur, control and extinguishing techniques should be applied. Any discussion of fire extinguishing mediums in use today immediately assumes the aspect of a highly controversial subject, and one which is difficult to present without apparent criticism of the medium itself, the equipment which is used, the techniques with which it is applied, or the judgment of the user himself.

Taking these points into consideration, it should be stated very emphatically that in any discussion of the fire extinguishing techniques or materials, no criticism is meant toward past efforts of those who have borne or are bearing the prime responsibilities for controlling and extinguishing fires whether it be in industries, municipalities, or elsewhere.

Fires services are improving in the development of means of mastery over fire.

Much Progress. Men started with the well known bucket brigade. Then, pumps and improved hose stream application came into being. Finally, the technique to break water down into small particles in order to increase its heat absorption efficiency, extended its extinguishing ability.

With the development of more important techniques water is being used with greater effectiveness in both portable and fixed protection facilities. The indirect application of high velocity fog into the heated areas of fires in enclosed spaces is a good example. The details of such an application are also the subject of an NFPA publication.

Through chemistry, additives are available that will appreciably increase the fire extinguishing efficiency and broaden the use of water. These additives give naturally occurring waters the ability to spread farther and penetrate deeper to form blankets of foam, even when very small amounts of chemical solutions are added. Experience indicates that a combination of water with certain chemicals increases efficiency to the point where it may become an ideal and more universal extinguishing medium in the future.

Such extinguishing mediums as certain halogenated compounds, carbon dioxide, dry powder, and chemical foam are effective on some classes of fires.

Carbon dioxide, commonly referred to as CO_2, was recognized as a good fire extinguishing medium many years ago and the development is just about coming into its own.

Dry powder as an extinguishing medium is coming into prominence very rapidly, and some authorities find that the use of carbon dioxide or the dry powder, and water with chemical additives, provide the most universal approach to fire extinguishment that has ever been developed.

Chemical and mechanical foam solutions, which are also based on chemical additives, are very effective and are a requirement on some types of flammable materials.

Nothing New. It is interesting to note that the development of such materials as carbon dioxide, dry powder and chemical foam were all developed in Germany some 55 or 60 years ago, however, it was not until some 30 to 50 years later that they began to come into prominent use in the U. S. This is an example of our reluctance to accept the other fellow's ideas and his data. Most any of these mediums do not put fire out any faster or more efficiently today than they did in Germany 60 years ago, but it must be realized that they do have a very definite place in our fire extinguishing techniques.

Probably the greatest resistance to using anything but plain water as a fire extinguishing medium can be traced to the cost of chemicals, etc. that have to be manufactured, while water is considered to be free. However, it costs a considerable amount of money to provide pumping equipment because water is not too effective unless it's applied under pressure. It is necessary to have projection, so that the extinguishing medium can be thrown, so to speak, into a fire. Therefore, energy is required to propel these extinguishing mediums. The cost of providing such energy sometimes is overlooked.

In Conclusion. Definite economies result from engineered fire safety, and help to insure continuous and efficient operation of manufacturing processes, as well as security and comfort for employes. A continuing objective program of fire safety by all industry may well equal in importance the objective program being so successfully carried on by the medical profession for the control or elimination of the many insidious diseases that plague mankind. ##

Foremen Should Know Labor Contracts

In order to maintain good labor relations, foremen should understand the basics of the Taft-Hartley Act and the workings of the collective bargaining procedure

Robley D. Stevens
Management Consultant
Washington, D. C.

AS A COMPETENT foreman in your refinery you are a member of your refinery management who has been delegated the authority to manage a department or operating group. You are the one the workers look to for orders, discipline and recognition; the one they look to for proper instructions and supervision; the one they call boss.

Thus, your contacts as a foreman with your workers and their unions must at all times be sincere. It is your responsibility as a foreman to respect and abide by the labor contract which your refinery and its employes' union have developed. By so doing you help promote better management-labor relations. Here are some important things you should keep in mind about this association.

Role of Collective Bargaining. It is true that under the Taft-Hartley Act, the term "to bargain collectively" means the performance of the mutual obligation of employer and employe representatives to meet at reasonable times and confer in good faith with respect to wages, hours, and other terms and conditions of employment; or the negotiation of an agreement, or any question arising thereunder; and the execution of a written contract incorporating any agreement reached if requested by either party. The one exception, however, is that this obligation does not compel either party to agree to a proposal or make a concession.

You can see, therefore, that it is necessary that you have this knowledge to prepare yourself for the day when you will attend a collective bargaining conference as a management representative. It is the starting point of every labor contract negotiation.

Approaches to Bargaining. Not all plants and unions look upon collective bargaining in the same manner. Each one has a different goal and objective.

Probably the most common type of bargaining is that based upon the concept of horse-trading. When this type of bargaining exists around a conference table, each side makes certain demands upon the other and then trades off one demand against the other. However, on a horse-trading basis refinery management will come well prepared to make numerous demands against the union and hold out for all of them up to a certain point. After that point, then the trading of demands will be skillfully conducted.

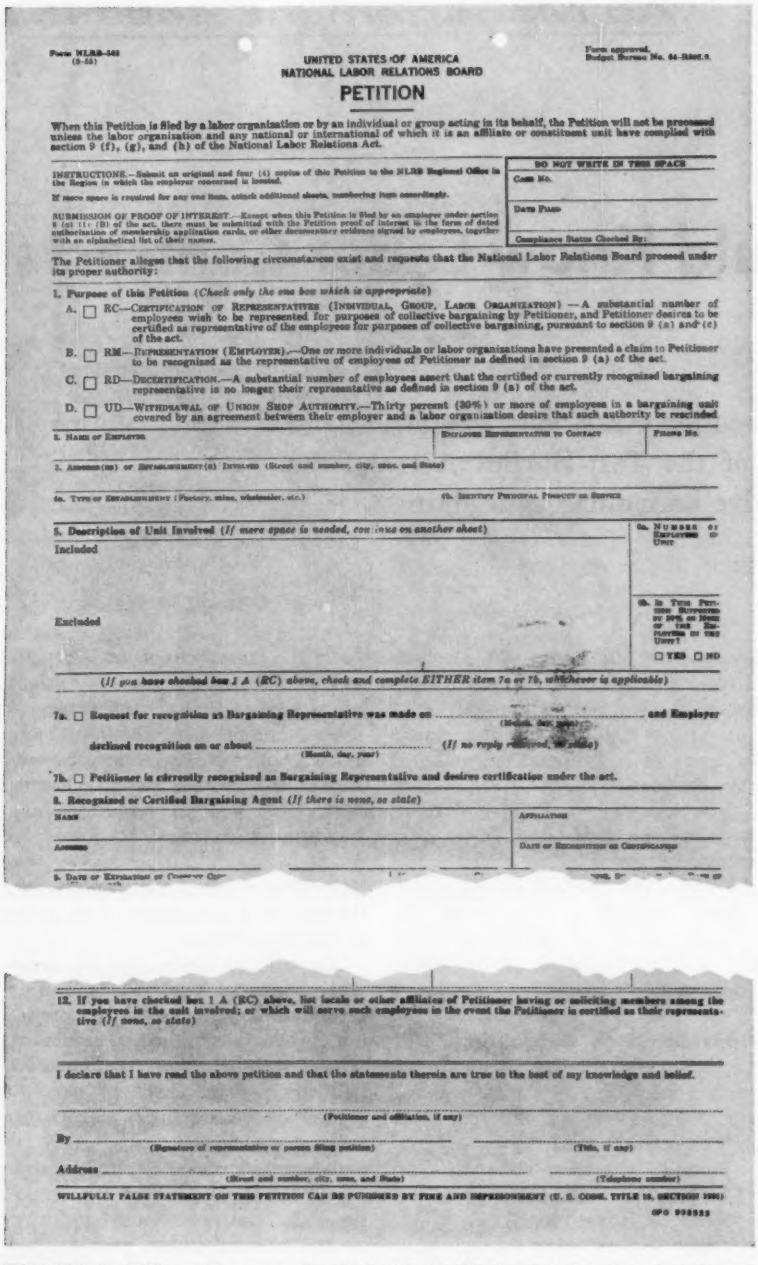
The Negotiating Team. It is true that the success and effectiveness of your refinery in negotiating a labor contract depends to a large extent upon the composition and experience of its negotiators. Thus, their selection is of utmost importance.

Your refinery negotiating team likely would be composed of a committee that would include, among others, the general superintendent, a personnel executive, an industrial relations expert, and perhaps a company lawyer. All of their knowledge, training and experience is of paramount importance.

There is no doubt that the union will choose its strongest leaders to submit their proposals to your refinery for consideration and approval. Also, a national union representative will more than likely be present. Therefore, your refinery negotiators must have many traits, such as patience, persuasiveness, understanding of the whole field of labor relations in the petroleum industry, ability to resist union pressure tactics, and common sense.

As a refinery foreman you may be called upon to serve on the negotiating committee because your main function in the collective bargaining process is to take over after a labor contract has been negotiated by your refinery and help put it into operation. In so doing, this experience will give you a better idea as to what it is all about when the time comes for you to aid in putting your refinery labor contract into operation.

Under the Taft-Hartley Act, management negotiators must nego-



Form NLRB-502 (9-55)

UNITED STATES OF AMERICA
NATIONAL LABOR RELATIONS BOARD

Form approved. Budget Bureau No. 64-R002.9.

PETITION

When this Petition is filed by a labor organization or by an individual or group acting in its behalf, the Petition will not be processed unless the labor organization and any national or international of which it is an affiliate or constituent unit have complied with section 9 (f), (g), and (h) of the National Labor Relations Act.

INSTRUCTIONS.—Submit an original and four (4) copies of this Petition to the NLRB Regional Office in the Region in which the employer concerned is located.

If more space is required for any one item, attach additional sheets, numbering item accordingly.

SUBMISSION OF PROOF OF INTEREST.—Except when this Petition is filed by an employer under section 9 (c) (1) (B) of the act, there must be submitted with the Petition proof of interest in the form of dated authorization of membership application cards, or other documentary evidence signed by employees, together with an alphabetical list of their names.

DO NOT WRITE IN THIS SPACE

Case No.

Date Filed

Compliance Status Checked By:

The Petitioner alleges that the following circumstances exist and requests that the National Labor Relations Board proceed under its proper authority:

1. Purpose of this Petition (*Check only the one box which is appropriate*)

A. ☐ RC—Certification of Representatives (Individual, Group, Labor Organization) —A substantial number of employees wish to be represented for purposes of collective bargaining by Petitioner, and Petitioner desires to be certified as representative of the employees for purposes of collective bargaining, pursuant to section 9 (a) and (c) of the act.

B. ☐ RM—Representation (Employer).—One or more individuals or labor organizations have presented a claim to Petitioner to be recognized as the representative of employees of Petitioner as defined in section 9 (a) of the act.

C. ☐ RD—Decertification.—A substantial number of employees assert that the certified or currently recognized bargaining representative is no longer their representative as defined in section 9 (a) of the act.

D. ☐ UD—Withdrawal of Union Shop Authority.—Thirty percent (30%) or more of employees in a bargaining unit covered by an agreement between their employer and a labor organization desire that such authority be rescinded.

2. Name of Employer | Employer Representative to Contact | Phone No.

3. Address(es) of Establishment(s) Involved (Street and number, city, zone, and State)

4a. Type of Establishment (Factory, mine, wholesaler, etc.) 4b. Identify Principal Product or Service

5. Description of Unit Involved (*If more space is needed, continue on another sheet*)

Included

Excluded

5a. Number of Employees in Unit:

5b. Is This Petition Supported by 30% or More of the Employees in the Unit?

☐ YES ☐ NO

(*If you have checked box 1 A (RC) above, check and complete EITHER item 7a or 7b, whichever is applicable*)

7a. ☐ Request for recognition as Bargaining Representative was made on (Month, day, year) and Employer declined recognition on or about (Month, day, year) (*If no reply received, so state*)

7b. ☐ Petitioner is currently recognized as Bargaining Representative and desires certification under the act.

8. Recognized or Certified Bargaining Agent (*If there is none, so state*)

Name | Affiliation

Address | Date of Recognition or Certification

9. Date of Expiration of Current Con[illegible]

12. If you have checked box 1 A (RC) above, list locals or other affiliates of Petitioner having or soliciting members among the employees in the unit involved; or which will serve such employees in the event the Petitioner is certified as their representative (*If none, so state*)

I declare that I have read the above petition and that the statements therein are true to the best of my knowledge and belief.

(Petitioner and affiliation, if any)

By (Signature of representative or person filing petition) (Title, if any)

Address (Street and number, city, zone, and State) (Telephone number)

WILLFULLY FALSE STATEMENT ON THIS PETITION CAN BE PUNISHED BY FINE AND IMPRISONMENT (U. S. CODE, TITLE 18, SECTION 1001)

GPO 9[illegible]

FIGURE 1—This petition must be filed with the National Labor Relations Board by either an employer or labor union. It is used to establish or rescind a group or individual as the bargaining agent for the employes involved.

tiate in good faith, try to understand the other party, make every effort to avoid personalities, and keep an open and alert mind. They also will have to deal with facts and reason, not personal opinions or emotions.

Refinery Conference. Of course, negotiators will not wait until the day before the first meeting of the bargaining conference takes place. For as many weeks as are available prior to the meeting, they will be making adequate preparation such as gathering all available and pertinent information concerning wages, benefits, hours of work, and employment conditions. On the other hand, the union will also be conducting a similar study. Union representatives will have to know and understand before they go into the conference just how far your refinery will go on contract negotiations and the other demands a union usually makes.

Certainly, your refinery will have sufficient advance notice about pending contract negotiations. If there's any doubt of the union's claim that it represents a majority of your refinery employes, your management may request that the National Labor Relations Board conduct an election to determine the question.

If your refinery has a labor contract, your negotiators must be familiar with the contract deadline and realize the coming necessity of negotiating a new one. The intervening time would be spent in gathering facts, figures, and general data in preparation.

Anticipate Demands. Your refinery negotiators will try to anticipate what demands are likely to be presented by the union since the union will take the initiative to present them. They will have to listen to the union's proposals, and determine which of them make sense and are practical for adoption by your refinery.

If a union has been certified by the NLRB, regardless of the time of the year, it will demand a conference. However, your refinery probably will prefer to engage in negotiations during some slack period of the year. Should negotiations break down and a strike result, the effect upon your refinery would be less serious.

No set rule can be laid down for the length of the bargaining sessions. Many feel, however, that after the parties have met it is well to drive through to a contract.

The matter of keeping a record of the bargaining proceedings is important. Your plant should keep a stenographic record as no doubt it will be referred to for reference.

Selection of Representatives. As a foreman you should understand that according to the Taft-Hartley Act, representatives designated or selected for collective bargaining by the majority of employes shall be the exclusive representative of all employes. This includes bargaining in respect to rates of pay, wages, hours of employment or other conditions.

In order to achieve recognition, however, an individual or group

must first file a petition on NLRB Form 502 shown in Figure 1. This form is used for four specific purposes:

1. Certification of Representatives—When a substantial number of employes wish to be represented for purposes of collective bargaining by the person or group filing the petition.

2. Representation—Filed by an employer when one or more individuals present a claim to be recognized as the representative of the employes.

3. Decertification—When a substantial number of employes assert that the certified or currently recognized bargaining representative is no longer their representative.

4. Withdrawal of Union Shop—When 30 percent or more of employes in a bargaining unit covered by an agreement between their employer and a labor organization desire that such authority be rescinded.

You can see, therefore, that the National Labor Relations Board has been given the right to decide what unit is appropriate, proper or fitting for bargaining purposes. However, Congress made the following exceptions:

1. Professional workers have a right to decide if they will be included in a group of non-professional workers.

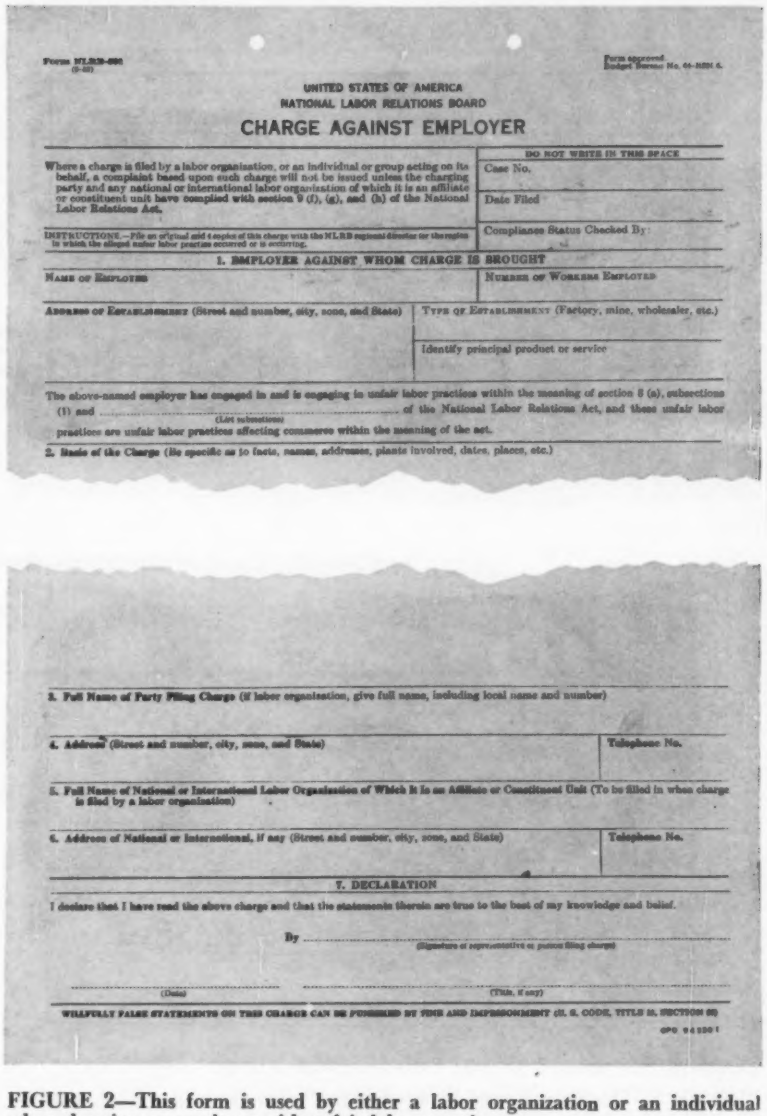
2. Craft units have a right to vote for or against separate representation.

3. Plant guards must be in a unit appropriate from all other types of workers.

You should also keep in mind that any individual employe has the right at any time to present grievances to his employer through the labor union, or if he wishes, individually, without the intervention of the bargaining representative (Fig. 2). If he does this individually, however, the adjustment may not be inconsistent with the terms of the labor contract.

By the same token, an employer can also file a complaint with the NLRB charging unfair labor practices (Fig. 3).

What About Free Speech? As a refinery foreman you should know and understand that the Taft-Hartley Act provides that, "The expressing of any views, arguments, or opinions, or the dissemination



Form NLRB-508 (5-57) — Form approved Budget Bureau No. 64-R014.5.

UNITED STATES OF AMERICA
NATIONAL LABOR RELATIONS BOARD

CHARGE AGAINST EMPLOYER

DO NOT WRITE IN THIS SPACE

Where a charge is filed by a labor organization, or an individual or group acting on its behalf, a complaint based upon such charge will not be issued unless the charging party and any national or international labor organization of which it is an affiliate or constituent unit have complied with section 9 (f), (g), and (h) of the National Labor Relations Act.

Case No.

Date Filed

INSTRUCTIONS.—File an original and 4 copies of this charge with the NLRB regional director for the region in which the alleged unfair labor practice occurred or is occurring.

Compliance Status Checked By

1. EMPLOYER AGAINST WHOM CHARGE IS BROUGHT

Name of Employer

Number of Workers Employed

Address of Establishment (Street and number, city, zone, and State)

Type of Establishment (Factory, mine, wholesaler, etc.)

Identify principal product or service

The above-named employer has engaged in and is engaging in unfair labor practices within the meaning of section 8 (a), subsections (1) and ..... of the National Labor Relations Act, and these unfair labor (List subsections)
practices are unfair labor practices affecting commerce within the meaning of the act.

2. Basis of the Charge (Be specific as to facts, names, addresses, plants involved, dates, places, etc.)

3. Full Name of Party Filing Charge (If labor organization, give full name, including local name and number)

4. Address (Street and number, city, zone, and State)

Telephone No.

5. Full Name of National or International Labor Organization of Which It Is an Affiliate or Constituent Unit (To be filled in when charge is filed by a labor organization)

6. Address of National or International, if any (Street and number, city, zone, and State)

Telephone No.

7. DECLARATION

I declare that I have read the above charge and that the statements therein are true to the best of my knowledge and belief.

By .....
(Signature of representative or person filing charge)

(Date)

(Title, if any)

WILLFULLY FALSE STATEMENTS ON THIS CHARGE CAN BE PUNISHED BY FINE AND IMPRISONMENT (U. S. CODE, TITLE 18, SECTION 80)

GPO 941201

FIGURE 2—This form is used by either a labor organization or an individual when charging an employer with unfair labor practices.

thereof, whether in writing, printed, graphic, or visual form, shall not constitute or be evidence of an unfair labor practice under any of the provisions of this Act, if such expression contains no threat of reprisal or force or promise of benefit."

It's clear that the problem of freedom of speech, especially as it applies to your employer, becomes an important question under the Act and you should understand its meaning.

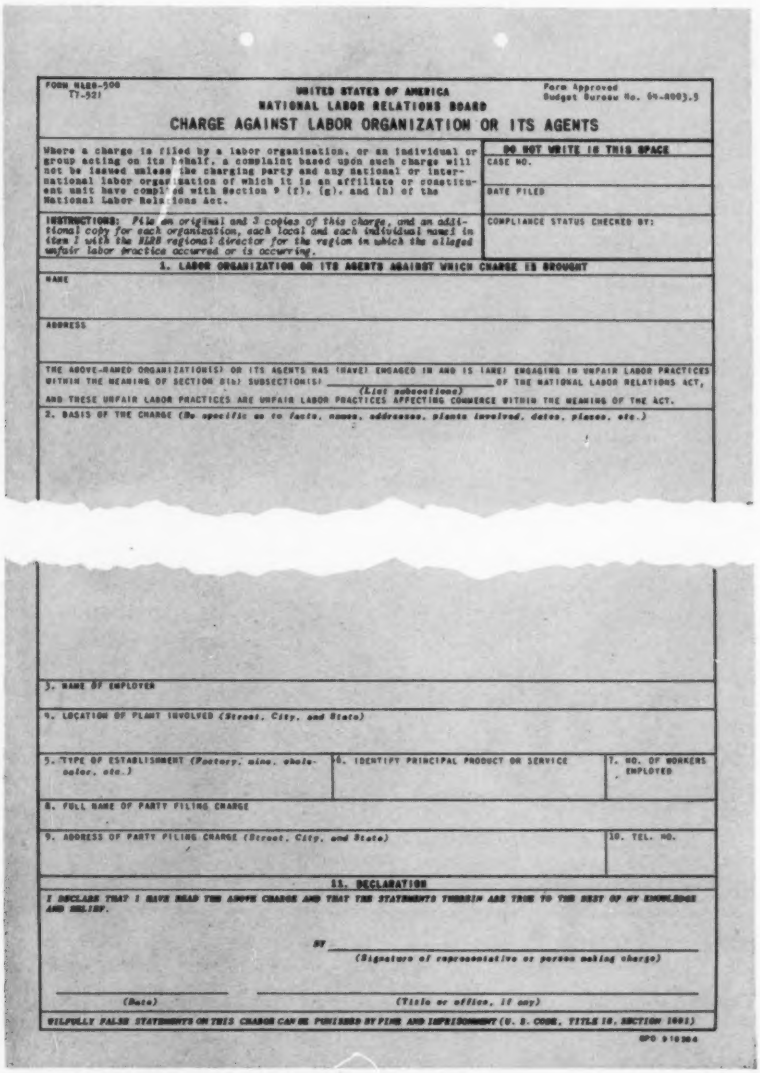
Modifying and Terminating the Contract. If one party to an existing contract wants to change it, here is what he must do:

1. Serve a written notice on the other party 60 days before the date the contract is to end or, if it has no termination date, 60 days before the proposed termination or modification.

2. Offer to meet and confer in order to negotiate a new contract or a contract containing the proposed modifications or changes.

3. Notify the Federal Mediation and Conciliation Service (as well as any State mediation agency) within 30 days after the first notice if no agreement has been reached.

4. Continue the existing contract in full force and effect without



FORM NLRB-508 (T7-521)

UNITED STATES OF AMERICA
NATIONAL LABOR RELATIONS BOARD

Form Approved Budget Bureau No. 64-R003.5

CHARGE AGAINST LABOR ORGANIZATION OR ITS AGENTS

Where a charge is filed by a labor organization, or an individual or group acting on its behalf, a complaint based upon such charge will not be issued unless the charging party and any national or international labor organization of which it is an affiliate or constituent unit have complied with Section 9 (f), (g), and (h) of the National Labor Relations Act.

DO NOT WRITE IN THIS SPACE

CASE NO.

DATE FILED

COMPLIANCE STATUS CHECKED BY:

INSTRUCTIONS: File an original and 3 copies of this charge, and an additional copy for each organization, each local and each individual named in item 1 with the NLRB regional director for the region in which the alleged unfair labor practice occurred or is occurring.

1. LABOR ORGANIZATION OR ITS AGENTS AGAINST WHICH CHARGE IS BROUGHT

NAME

ADDRESS

THE ABOVE-NAMED ORGANIZATION(S) OR ITS AGENTS HAS (HAVE) ENGAGED IN AND IS (ARE) ENGAGING IN UNFAIR LABOR PRACTICES WITHIN THE MEANING OF SECTION 8(b) SUBSECTION(S) _____ OF THE NATIONAL LABOR RELATIONS ACT, (List subsections)
AND THESE UNFAIR LABOR PRACTICES ARE UNFAIR LABOR PRACTICES AFFECTING COMMERCE WITHIN THE MEANING OF THE ACT.

2. BASIS OF THE CHARGE (Be specific as to facts, names, addresses, plants involved, dates, places, etc.)

3. NAME OF EMPLOYER

4. LOCATION OF PLANT INVOLVED (Street, City, and State)

5. TYPE OF ESTABLISHMENT (Factory, mine, wholesaler, etc.)

6. IDENTITY PRINCIPAL PRODUCT OR SERVICE

7. NO. OF WORKERS EMPLOYED

8. FULL NAME OF PARTY FILING CHARGE

9. ADDRESS OF PARTY FILING CHARGE (Street, City, and State)

10. TEL. NO.

11. DECLARATION

I DECLARE THAT I HAVE READ THE ABOVE CHARGE AND THAT THE STATEMENTS THEREIN ARE TRUE TO THE BEST OF MY KNOWLEDGE AND BELIEF.

BY _____
(Signature of representative or person making charge)

(Date)

(Title or office, if any)

WILFULLY FALSE STATEMENTS ON THIS CHARGE CAN BE PUNISHED BY FINE AND IMPRISONMENT (U. S. CODE, TITLE 18, SECTION 1001)

GPO 910304

FIGURE 3—This form is used by an employer when charging a labor organization with unfair labor practices.

a strike or lockout for 60 days following notice, or until the date the labor contract is to end, whichever is later.

Your Status As A Foreman. You have a right to decide if you will join a labor union. According to the Taft-Hartley Act, you are a supervisor because you are an individual having authority, in the interest of your employer, to hire, transfer, suspend, lay off, recall, promote, discharge, assign, reward, or discipline other employes. You direct them, adjust their grievances, and recommend action, if in connection with the foregoing, the exercise of authority is not of a merely routine or clerical nature, but requires the use of independent judgment.

Before the Taft-Hartley Act came along you may have questioned your standing as a foreman or supervisor. Now there should be no doubt if you meet the requirements by an act of Congress. Should union pressure be exerted upon you as a refinery foreman you should keep this in mind.

Making the Contract Work. There must be complete understanding in every collective bargaining conference between management and union. After the labor contract has been signed, it then has to be put into effect. In order to do this with the least friction possible, an effort should be made to inform every employe covered as to the contract provisions. In addition, as a foreman you must know and understand the provisions of the labor contract since you will have an important part in helping to put it into action and seeing that it works smoothly and satisfactorily.

Naturally, your refinery will have to comply with the terms of the collective bargaining contract. Failure to do so might lead to a strike or to a suit for breach thereof.

Other Pointers. You can see that there is nothing in the Taft-Hartley Act that forces you as a refinery foreman to meet the demands of a union or to give in to it during the bargaining process. The act has a special provision applying to you as a supervisor and you do not have the status of employes under it. Thus, though you may organize a union, it would not have the protection of the Act.

You should keep in mind that a collective bargaining contract is no different from any other body of rules or law; no matter how carefully the parties involved may attempt to do so they cannot answer every day-to-day question or problem. Often, the terms of the contract are subject to conflicting interpretations, just as are federal and state statutes. To meet this need or situation, your refinery and the union will ordinarily include grievance procedures which permit either party to make grievances of questions or problems not clearly answered by the agreement itself.

Negotiating a labor contract is not simple. It requires knowledge, experience and training. But there is no reason why you a refinery foreman cannot learn and understand your rights under the labor contract.

Most workers in your refinery feel that what you as a foreman say and do represents management. If they like the way you run your department and handle people, they will produce more and as a result morale will be high. Good leadership on your part will go a long way in helping you understand your refinery labor contract and solve management-labor problems.

# #

Phillips Committee Manages Engineers

In order to cope with ever-increasing problems of manpower management, Phillips' Natural Gasoline Department's Operating Division established a technical personnel committee. Since then, this commmittee has been a smooth system of technical personnel management

T. G. Jackson, Phillips Petroleum Co.
Bartlesville, Okla.

THE OLD SAW that anything as ugly as a camel must have been invented by a committee finds ready agreement from most conference weary businessmen. Yet, the Natural Gasoline Department of Phillips Petroleum Co., is utilizing a committee to do an effective management job where nothing else seemed to work as well.

The Natural Gasoline Department's Operating Division is divided into three geographical districts, each with a local headquarters staff, including an engineering section. Approximately 50 percent of the engineers work in the Operating Division, about 40 percent in the Engineering and Construction Division (mostly located in the home office), and the other 10 percent in five remaining divisions. The division heads report directly to the department manager. Practically all young engineers are first employed in the Operating Division's district locations. Manpower needs of the Engineering Division are normally filled by transferring Operating Division engineers who have completed the formal training program and who have actual plant and field engineering experience.

Administrative Nightmare. Through the years as the staff grew, manpower management problems became more pronounced. The division of responsibility was fraught with the makings of an administrative nightmare. Although engineering manpower was divided almost equally between two divisions, one division hired and trained all new men for the department. Engineering and other divisions had to petition the Operating Division for replacements or additions to their staffs.

The Operating Division engineering supervisors, in position to observe young engineers in training and at work, were the only competent judges of who was the best prospect for advancement. When parallel opportunities existed simultaneuosly in the two divisions, field supervisors had to reach decisions that would try the objectivity of Solomon. With a large engineering staff and a generous sprinkling of engineers in responsible administrative and operations jobs, openings occurred frequently for experienced engineers to advance to first line and intermediate supervisory and administrative jobs in the various divisions. However, some of the more specialized jobs in the department required careful training, job experience and sometimes even necessitated hiring specific types of engineers.

In 1957 the department established a technical personnel committee to consider and make recommendations on technical personnel problems. Committee members were the three district engineers and the three section heads of the Engineering Division with the assistant director of the Engineering Division and the assistant director of the Employee Relations Division

acting as non-voting (except in case of ties) co-chairmen. Concurrently, responsibility for recruiting and employing engineers was transferred to Employee Relations.

The technical personnel committee has no authority or line responsibility as its function is to make personnel recommendations to the appropriate division head. Original plans were to meet quarterly. However, meetings have averaged about six a year. While the committee is concerned with all personnel matters relating to engineers, there are certain areas which it has followed closely because of their departmental significance.

1. Placement. Since committee members supervise 90 percent of the department's engineers, they are well fitted to choose and recommend individuals for advancement to first line and intermediate supervisory and administrative jobs as they become vacant. Much of this planning is done on a long range basis, and individual engineers are steered toward necessary work experience to qualify them for the big opportunity when it comes. Many transfers between districts and the home office are required to properly man the organization, and much committee time is spent deliberating such transfers in order to maintain an equitable balance between individual career advancement and departmental work efficiency.

As engineers grow older, we are also faced with a timing problem—coordinating transfers where possible with school terms. It is an extremely rare occasion when management does not accept the committee's recommendations concerning a promotion or transfer.

2. Salary Administration. The technical personnel committee devotes one meeting late in each year to a discussion of salary administration for the succeeding year. This has resulted in a much better correlation of salary treatment of engineers at various locations. Incidentally, it has also provided an excellent means of evaluating individuals for future promotion, since discussion of merit increases necessitates comparison of capabilities and performance. Other salary administration problems have been handled from time to time, as assigned by management.

3. Proper Utilization of Engineering Staff. The committee has actively worked toward effective utilization of engineering talent through the delegation of non-technical, routine and clerical work to technicians and clerical personnel. It has sponsored utilization studies to delineate areas where delegation can be made. Although much work remains to be done in this field, this program has already contributed much to the upgrading and professionalization of our engineering jobs.

4. Employment. Composed of members whose regular jobs are in a direct line of authority over most of the department's engineering work, the committee naturally is highly conscious of manpower problems. It furnishes guidance to the personnel staff in determining standards and setting hiring quotas for management approval. This is done by considering the immediate and long range needs of the entire department, and balancing quotas of types of engineers to be hired against the anticipated combined needs of all divisions. Once the standards are set, the personnel staff is held responsible for hiring the best men available within those standards. This allows us to hire and assign engineers on a departmental basis.

5. Training. The committee is considered the sponsor of the formal training program for young engineers. Upon recommendation of the committee following a detailed study, the formal training was recently condensed from 12 to 6 months. Normally, formal training is concentrated in the field and in one district. The resulting concentration of young engineers is resolved by apportioning them, upon completion of training, to other areas where they are trained in specific jobs. The apportionment is made by, or with the concurrence of, the committee. This is actually the beginning of the planned development of the individual engineer, as discussed earlier in the "Placement" section.

Probably no committee has ever operated on a completely unanimous basis, and this committee is no exception. Unanimity on all questions could only mean that one person dominated or that matters discussed were completely non-controversial. No doubt most people will agree that it would be impossible for seven engineers to sit in any meeting, particularly a meeting on personnel matters, for more than a few minutes without an honest diversion of opinion. The addition of a personnel man in our case does not seem to particularly detract from the number of disagreements.

One of the valuable benefits derived from this committee's work is a by-product. This unexpected dividend comes from the fact that supervisors working on employee development in turn are developing their personal management abilities and capacities. Some supporting evidence of this is established by rather rapid turnover in the committee, occasioned by promotion of members to higher level management jobs. While such promotions could hardly be attributed solely to committee membership, this experience in considering personnel problems from a broad, departmental viewpoint assists materially in developing the participants in one of the most important prerequisites to advancement—management perspective. ##

About the Author

T. G. Jackson received his B.S. degree in 1937 from North Texas State College at Denton. In 1942 he joined Phillips Petroleum Co. in the Natural Gasoline Department. Since that time he has served in numerous field and home office personnel jobs. Since 1951 he has been assistant employee relations director for the Natural Gasoline Department.

Test Yourself on Labor Relations

No. 1 Holiday Pay When Laid Off?

The company had a standard holiday pay policy—if an employe worked on the day before and the day after a holiday, he was paid for the holiday.

Because the plant was being moved to another area, five employes were terminated. They had vacation pay coming, which was included in their final check.

Under normal conditions, these employes would have taken their vacations in late May or early July. In either case, the vacation period would have embraced a paid holiday—(Memorial Day or July 4th)—and the employes would have collected an extra day. But because these employes were not around to take their vacations, due to the terminations, they were not entitled to the holiday pay. At least, so said the company. But the employes had a different view:

1. An employe who is laid off or terminated through no fault of his own is still technically an employe.
2. Under the seniority policy of the company, an employe does not lose his status until he has been off the payroll for a period of one year. Therefore, he cannot be denied benefits which would accrue.

The company answered further:

1. A worker is entitled to holiday pay only if he works before and after the holiday.
2. The employes were given vacation pay because they were being terminated. They were not on vacation and could not claim any pay for a holiday that fell during the vacation period. Besides, the vacation pay was really a form of severance.
3. A layoff is not the same as a termination. The employes' jobs were eliminated and the workers have no chance of recall. For this reason the employes do not retain the "status of employe" for one year.

Test Yourself:

Was the company: RIGHT ☐ WRONG ☐

No. 2 Poor Safety Record

When a new job opened up, the company posted the vacancy on the bulletin board. It has a policy of granting promotions on the basis of seniority and ability. Bill Johnson put in for the higher job—he being the top-seniority man in the lower grade. When he was bypassed for the promotion he raised his voice in protest.

The company produced records to show that Johnson had two warning slips for unsafe conduct on the job. Management also said that Johnson had to be constantly reminded about observing the safety precautions.

Johnson promised to be "safe" in the future and claimed that the company couldn't use two warning slips as a basis for not promoting a man. "It's rank discrimination," he charged.

Test Yourself:

Was Johnson: RIGHT ☐ WRONG ☐

No. 3 Working For Competitors

Armand Charpentier was a maintenance man. When overtime was cut in his department, he looked around for a part-time job to supplement his income, and found work with a competitive firm. When his boss discovered this he gave Armand a choice:

"Work for them or work for us. Which do you want?"

"I want to work for both," was the reply. When Armand refused to budge he was discharged. At arbitration he came up with the following arguments:

1. What I do on my own time is my own business.
2. I have no access to secret or confidential information. I'm a maintenance man and I fix machines.
3. My work is good here so you have no complaint.
4. You have no rule against working for competitors. This practice has been going on for years.

The company answered:

1. True we have no rule—but we can make a rule.
2. Maybe Armand does not have access to secrets, but he knows a lot of what's going on. We don't want our competitors to learn even harmless things about us from our own employes. We don't want to talk in whispers when Armand is around because we might feel something will get back.

Test Yourself:

Was the company: RIGHT ☐ WRONG ☐

Answers on Page 335

Simplicity In Decoking Manifold Design

Decoking furnace tubes is just a matter of heating them from the outside while steam blows coke from the coil. The problem lies in designing a simple manifold to do this

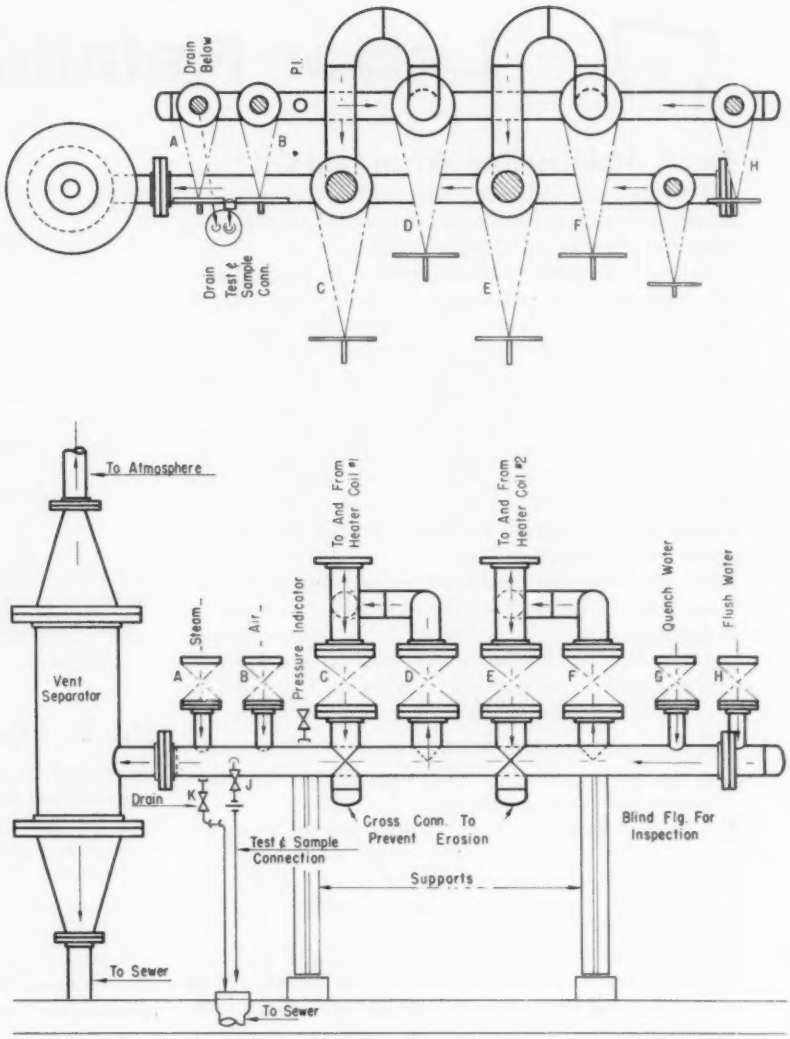


FIGURE 1

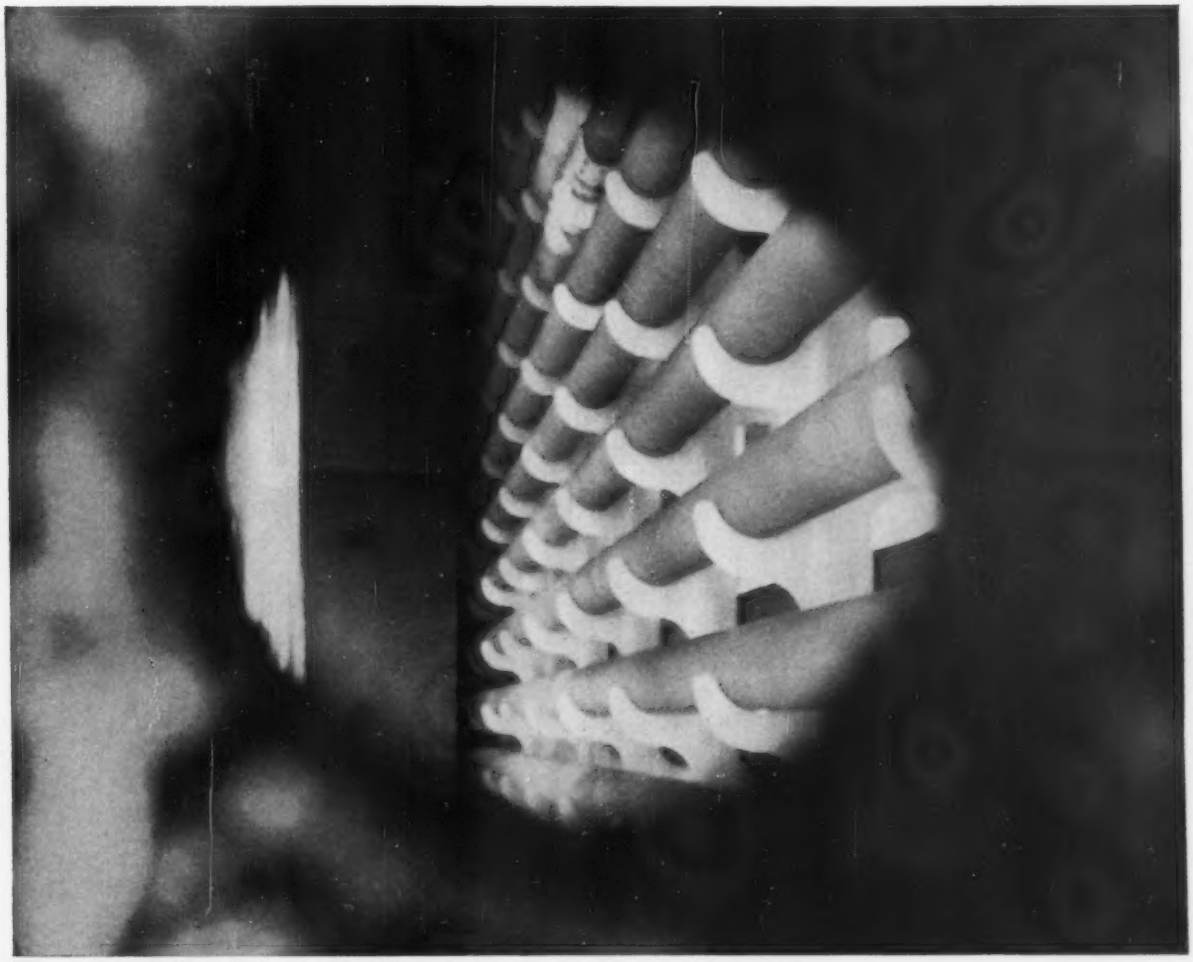
The design of a manifold to decoke furnaces with steam and air has always been associated with a maze of valves and piping. Although the principle of decoking is very simple, pipe designers usually become involved in such complicated piping arrangements that, invariably, the orthographic view is difficult to read without the aid of a supplementary isometric. This results not only in higher drafting costs, but in higher costs of piping, valving, and operation. The purpose of this article is to present a neat, simplified piping design for decoking manifolds that reduces these costs.

For the benefit of the reader who is not familiar with the mechanics of decoking, these consist merely of shrinking and cracking coke loose by heating the tubes of a furnace from the outside while steam blows coke from the coil.

Figure 1 shows a typical decoking flow diagram. The letters designating the valves on the flow diagram correspond to the valves on the manifold layout, Figure 2, (Page 222).

The simplified decoking manifold consists of two interconnected manifolds. One manifold serves as a steam, air, and flush water supplier; the other takes care of the effluent, quench water, and sample connection.

The effluent manifold requires only one test and sample connection, and one quench-water connection, because the manifold is common to both coils of the furnace even when decoking with reverse flow through the coils. This manifold is provided with a set of break flanges to serve as an inspection port for a periodic erosion check. Cross-like connections are provided at



The Inside Story tells...

Why Gulf Oil uses Incoloy alloy tubing in high temperature ethylene furnaces

In the manufacture of ethylene by pyrolysis of hydrocarbons, an important and complex metallurgical problem arises in the selection of material for furnace tubes.

The problem involves choosing a material with adequate high temperature properties, corrosion resistance and metallurgical stability.

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Incoloy alloy has outstanding resistance to corrosion, to oxidation, and to carburization. It has high creep strength, and metallurgical stability.

No sigma phase formation with Incoloy alloy. In the critical 1,100° to 1,600° F range, Incoloy alloy retains its resistance to impact and to thermal fatigue, and its ductility.

If the selection of furnace tube materials is your responsibility, you will want detailed information on the advantages of Incoloy alloy. It's so easy to get the facts. Just write to the Huntington Division.

Ni-o-nel alloy resists mixtures of hot acids Ni-o-nel* nickel-chromium-molybdenum alloy is a commercial alloy available in all standard mill forms including seamless tubing. Its physical and metallurgical properties and its resistance to corrosion are discussed in detail in our recently published Technical Bulletin, "Engineering Properties of Ni-o-nel." Write for a copy. Just ask for Bulletin T-37.

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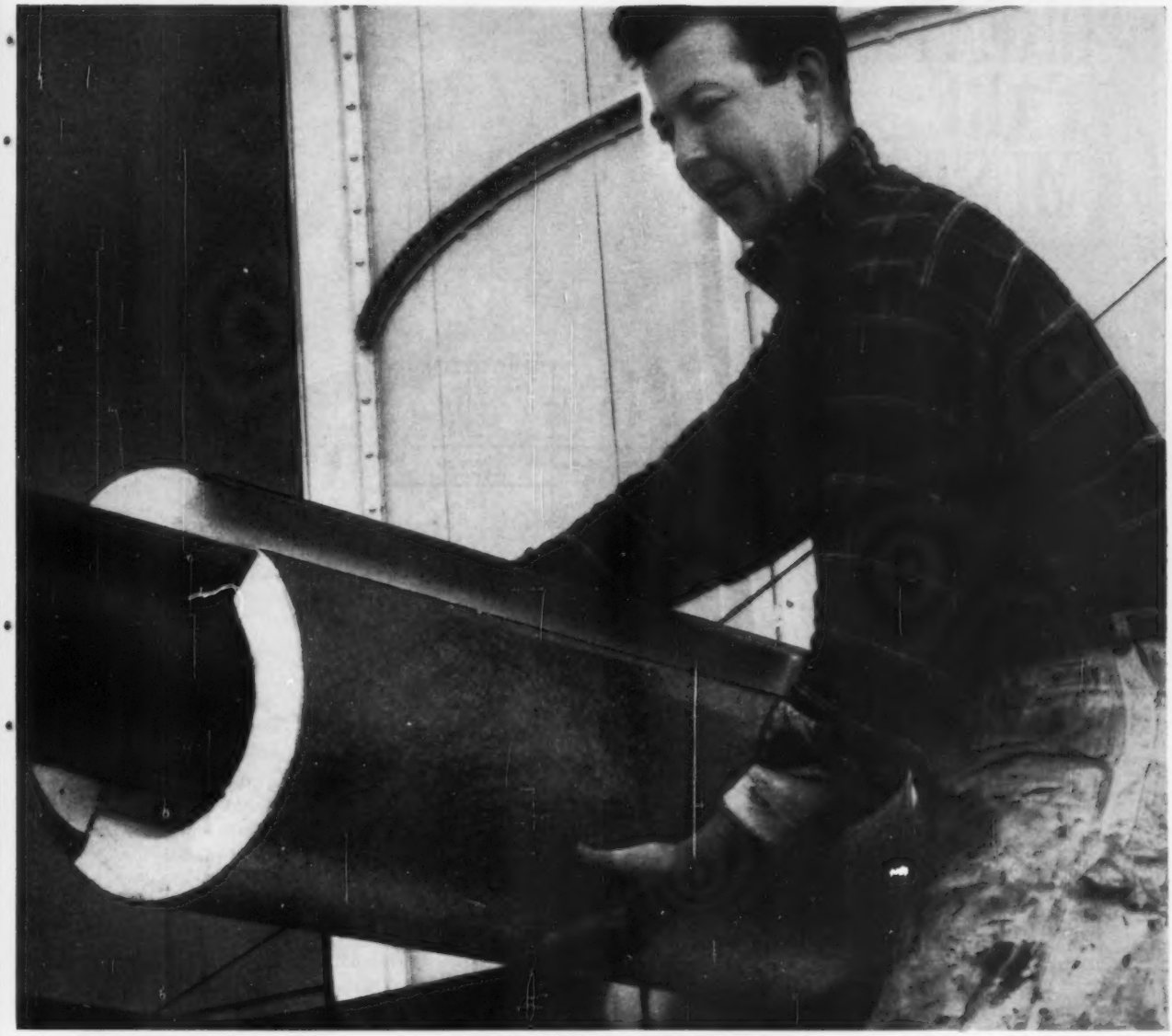
Now, efficient, high-temperature Kaylo Pipe Insulation comes with an embossed aluminum jacket that locks together in quick, one-step application. New jacket assures full weather protection and adds distinctive "no-glare" appearance.

This is new Kaylo-Klad: the famous efficiency of Kaylo Pipe Insulation factory-jacketed in thick (.016") embossed aluminum. Longitudinal seam of jacket snaps together with interlocking lips for positive weather tightness in one, quick step. End joints are sealed with a band containing an integral sealing compound.

Aluminum jacket provides greater resistance to mechanical damage and embossed, rippled texture diffuses light and eliminates glare, while dressing up line. Kaylo-Klad offers excellent thermal efficiency for temperatures up to 1200°F in all standard sectional pipe sizes and in thick-



nesses to 3". It is permanent, reusable, and fabricates with simple tools. A standard band saw or hacksaw makes quick, straight cuts and a saber saw makes cutouts for fittings and hangers.

New Kaylo-Klad is a superior, high-temperature pipe insulation for your industrial requirements. And remember, under the jacket is Kaylo, the universally accepted and field proven material with the most desired physical properties for an efficient, durable, high-temperature pipe insulation job. Write for new literature to: Owens-Corning Fiberglas Corporation, Department 55-C, Sales Division—717 Fifth Ave., New York 22, N.Y.

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If you need a phosphorus additive to eliminate engine knock, reduce surface ignition and spark plug fouling, you can rely on the experience and facilities of FMC. Write for more information about FMC gasoline additives. We will be glad to show how these products can meet your most exacting specifications.

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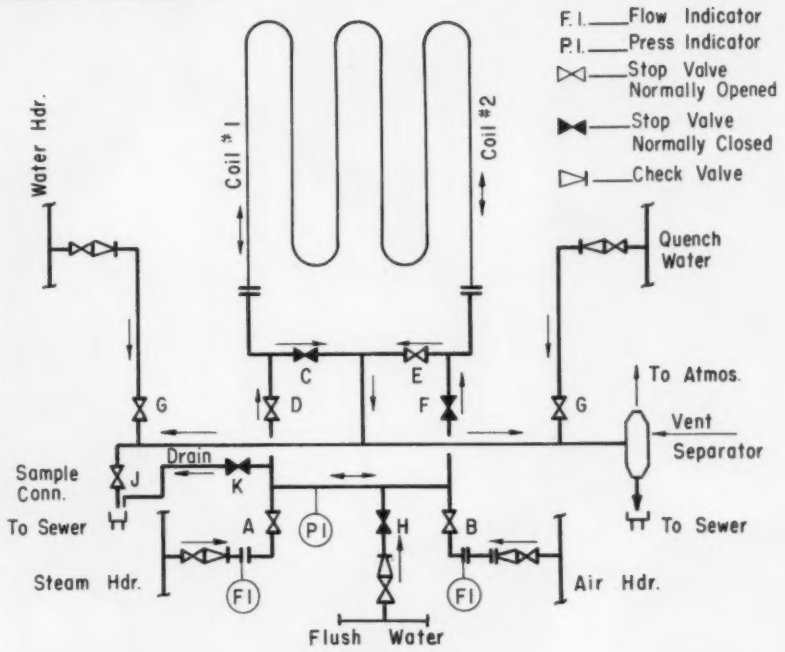


FIGURE 2

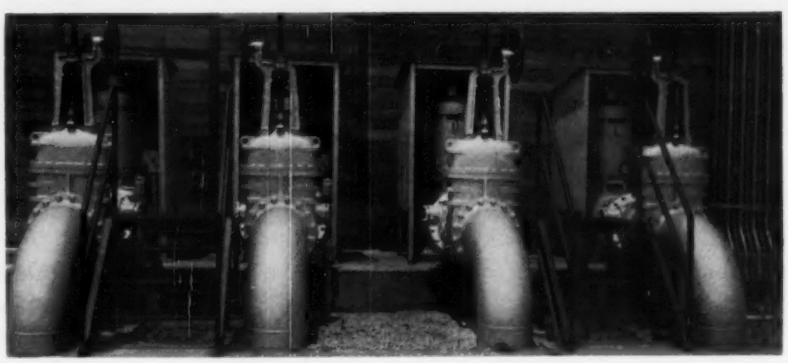
the change of direction of the effluent to prevent erosion.

In order to separate the non-condensable gases from the liquid effluent, a vent separator or knock-down drum is introduced prior to discharge of effluent to the sewer.

Most of the valves perform multiple service, thus eliminating the need for duplicate valves. With readily accessible valves, and symmetry of design, the decoking operation can be performed with ease.

Referring to Figure 2, note that the two valves "C" and "F" are normally closed when decoking through coil number one. When the flow is reversed, valves "D" and "E" are closed, and "C" and "F" are opened when decoking through coil number two.

This item was submitted by Anthony A. Romeo, who wrote this article while employed by James P. O'Donnell, New York. He is currently with Scientific Design Co., New York.



Penthouses Protect Cooling Tower Pumps

Pumps handling flow through or over a cooling tower are of the all-weather type, and are usually set on or adjacent to the edge of the tower foundation. On one such tower, where the prevailing winds blew across the tower toward the pump setting, wave action would build up atop the tower, with the result that appreciable amounts of water would slosh

1/2¢ Per Barrel Hydrotreating Catalyst

HARSHAW COBALT MOLYBDATE

Proven superiority where it counts—*long life* and *low cost*. Typical installations using Harshaw Cobalt Molybdate Catalyst and achieving catalyst costs of less than ½¢ per barrel:

a Hydrotreating cracked, high sulfur, high nitrogen stock: Catalyst retained high activity through over four years of service and 12 regenerations.

b Hydrotreating high sulfur straight run diesel oil: A first run of 2½ years without regeneration of the catalyst —and still going strong.

Active, rugged, and thermally stable, Harshaw Cobalt Molybdate Catalyst proves its superiority where it counts—with long life and resulting low cost. It can give you the type of performance cited above with any feedstock from low boiling naphthas to heavy vacuum distillates. In all applications, the long life of our catalyst reflects reduced per-barrel costs. For further information about this and other proven hydrotreating catalysts, contact the Harshaw branch nearest you.

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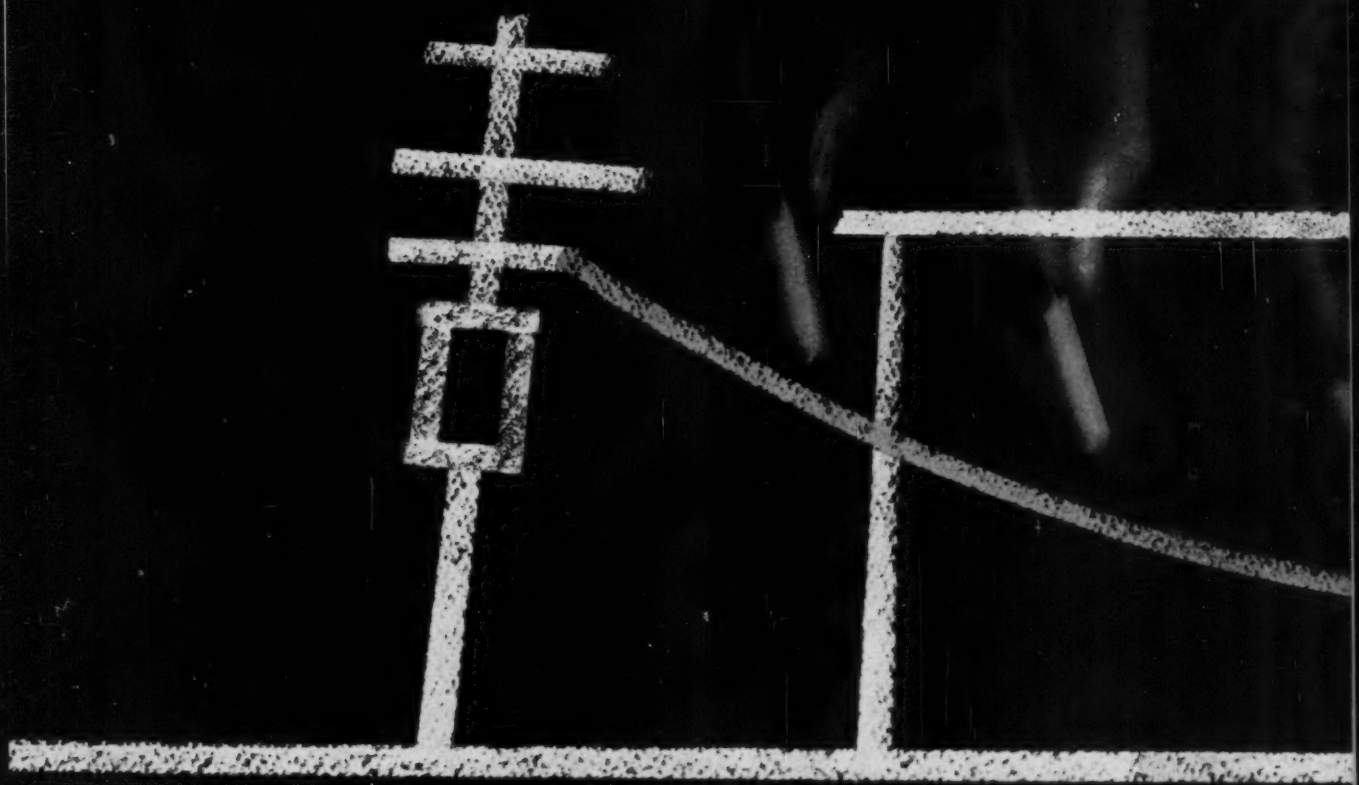

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One refinery actually tested the corrosion resistance of building wire *on the job:*

Regular TW . . . neoprene-covered . . . braided rubber-insulated . . . lead-covered . . . and *Rome Synthinol 901!*

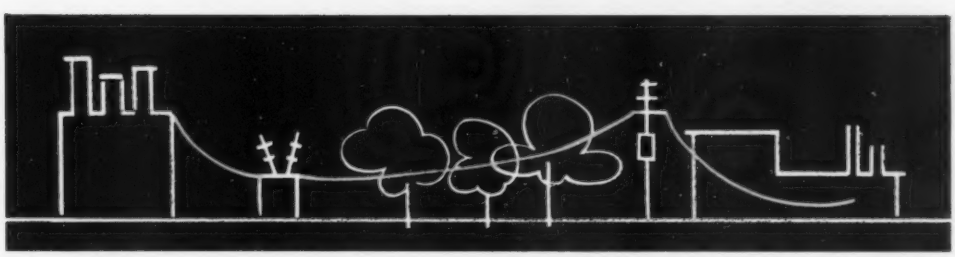
RESULT: Only Synthinol 901 and the lead-covered wire held up under exposure to corrosives.

BEST BUY: Rome Synthinol—lower in cost and easier to handle than lead-covered wire.

Synthinol 901 has been proved in the lab and on the job for its resistance to moisture, oil and corrosive vapors. You can recommend it to your industrial customers for any low-voltage application—600 volts and under—including control circuits, plant and refinery equipment, and general wiring of office and warehouse buildings.

Where higher than normal heat conditions exist, you can recommend Synthinol 901 for its superior heat-deformation resistance. You can even use it to replace varnished cambric insulation on oil-filled transformer leads, where the leads are constantly immersed in hot oil.

Get further information, including lab test results, on Rome Synthinol 901—yours for the asking from Rome. Just clip the coupon, mail it today!



Power source to plant—Rome Cable gives you the *right* answer to every wiring problem. Power station to substation: Rome's interlocked armored cable "installs like cable, protects like conduit." Substation to plant or refinery: Rome's preassembled aerial cable goes up fast—even through trees—and is well protected from storms. Inside plant or refinery: Rome Synthinol gives maximum corrosion resistance, assures dependable service.

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Penberthy ejectors are steam, air and liquid operated to transfer, heat, circulate, aerate, agitate, mix or pump liquids and to bleed and exhaust air or vapor and to produce vacuum.

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How To Do It . . .

over and cascade down across the pumps. This would interfere with proper cooling of the pump motors. and also leave exposed surfaces moist to assist in dirt adherence if the adjacent area was dry and dusty.

Penthouses, one for each pump. were designed with back and front open, the sides extending down to a foot above the foundation, and with a sloping roof higher at the face of the pumps. This housing did not interfere with inspection of the pump or motor, and could be removed for replacement of the wither unit simply by loosening the foundation bolts.

This tower also illustrated the application of engineering to operational simplification. By reversing the bracket which carried the spur (bevel) pinion on alternate units, the hand wheels were faced in pairs, and only two sets of steps and platforms were required. Four would have been needed had the set-up been conventional, with all hand wheels faced either to right or left. As the bracket is centered over the opening in the gate cover for the valve stem, it may be faced in either direction without requiring additional machining.

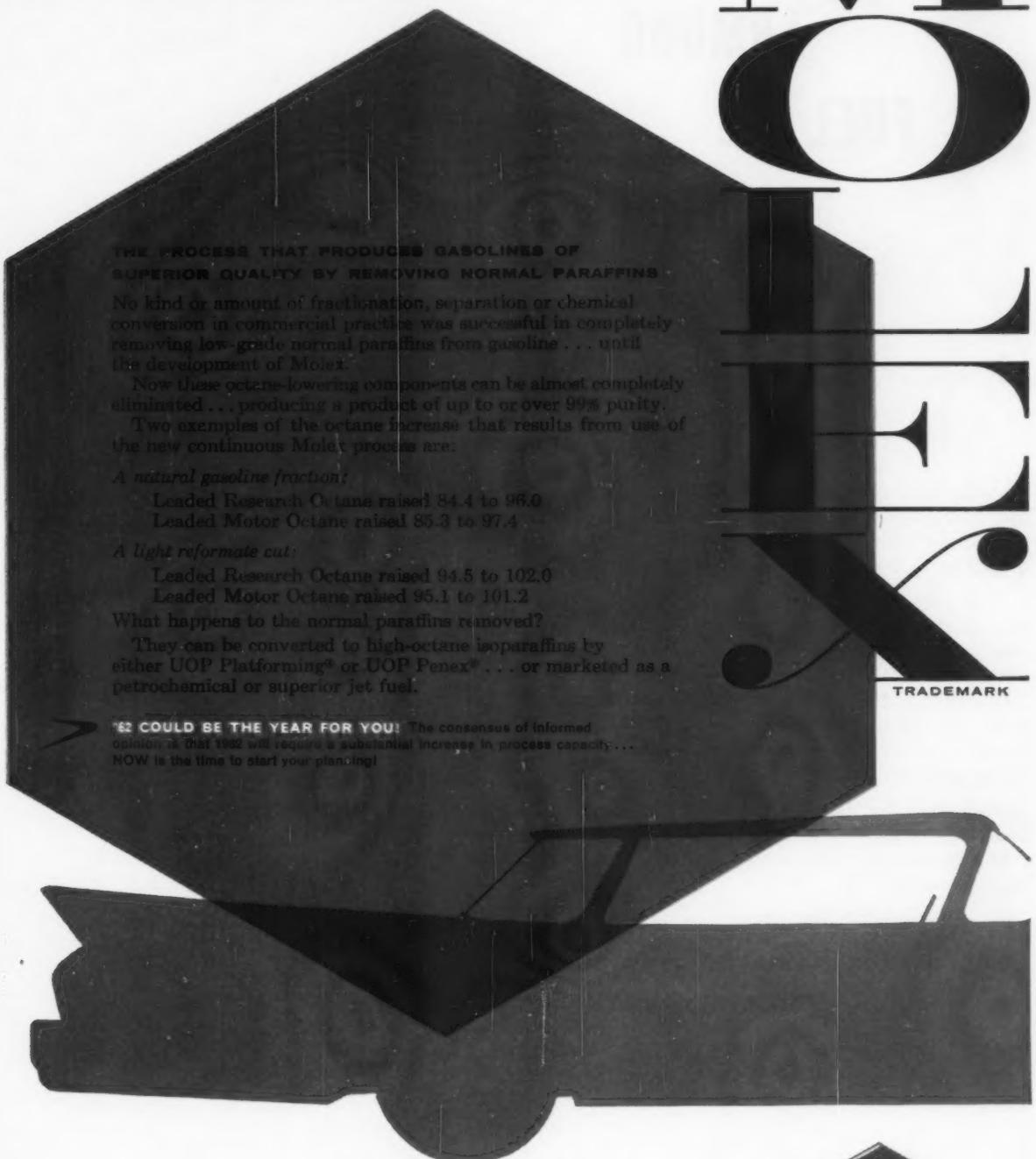
YOUR IDEAS ARE VALUABLE!

At least $10 will be paid for each idea accepted for "How to Do It." Just send a brief note with a photo or sketch to the Editor, *Petroleum Refiner*, P. O. Box 2608, Houston.

for superior motor fuels . . .

MOLEX

TRADEMARK



THE PROCESS THAT PRODUCES GASOLINES OF SUPERIOR QUALITY BY REMOVING NORMAL PARAFFINS

No kind or amount of fractionation, separation or chemical conversion in commercial practice was successful in completely removing low-grade normal paraffins from gasoline . . . until the development of Molex.

Now these octane-lowering components can be almost completely eliminated . . . producing a product of up to or over 99% purity.

Two examples of the octane increase that results from use of the new continuous Molex process are:

A natural gasoline fraction:

Leaded Research Octane raised 84.4 to 96.0
Leaded Motor Octane raised 85.3 to 97.4

A light reformate cut:

Leaded Research Octane raised 94.5 to 102.0
Leaded Motor Octane raised 95.1 to 101.2

What happens to the normal paraffins removed?

They can be converted to high-octane isoparaffins by either UOP Platforming® or UOP Penex® . . . or marketed as a petrochemical or superior jet fuel.

'62 COULD BE THE YEAR FOR YOU! The consensus of informed opinion is that 1962 will require a substantial increase in process capacity . . . NOW is the time to start your planning!

UNIVERSAL OIL PRODUCTS COMPANY

UOP®

WHERE RESEARCH TODAY MEANS PROGRESS TOMORROW

30 Algonquin Road
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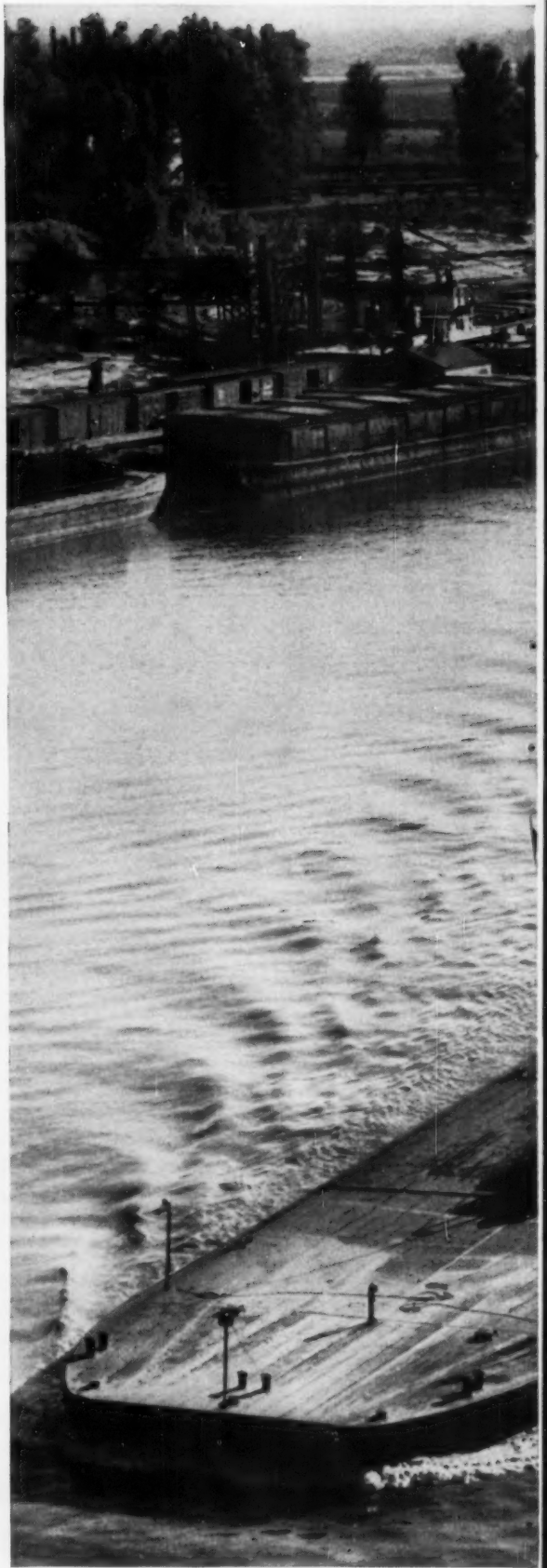
ARMOUR FUEL OIL ADDITIVES –

How they protect against sludge from refinery to furnace



Armolad® additives, Armour's furnace-oil stabilizers, are gaining wide acceptance as highly economical and effective sludge inhibitors. Using Armolads, refiners can stop worrying about additives that lose effectiveness while in transit or storage.

Fuel oil additives are subject to various conditions which can reduce their sludge-inhibiting properties. Major causes are: incompatibility with other additives, reaction with fuel contaminants themselves, and the presence of water—particularly in barges and storage tanks—which causes "leaching." Maintaining the effectiveness of the additive can only be achieved by increasing the concentration, which in turn raises costs unnecessarily.

Refiners using Armolads have found they are extremely resistant to water extraction, compatible with most other additives, help eliminate hazing, and will not react with fuel contaminants.

In addition, when fuel oil containing Armolads is pumped through the lines, monomolecular adsorption places a thin coating of the additive on the surfaces. This film offers resistance to corrosive action.

Armolads are available in several different formulations. Each has been found to suit the special needs of specific crude stocks. Additional information on these additives and their use is available by writing for the new booklet "Armolads."

Armour Industrial Chemical Company

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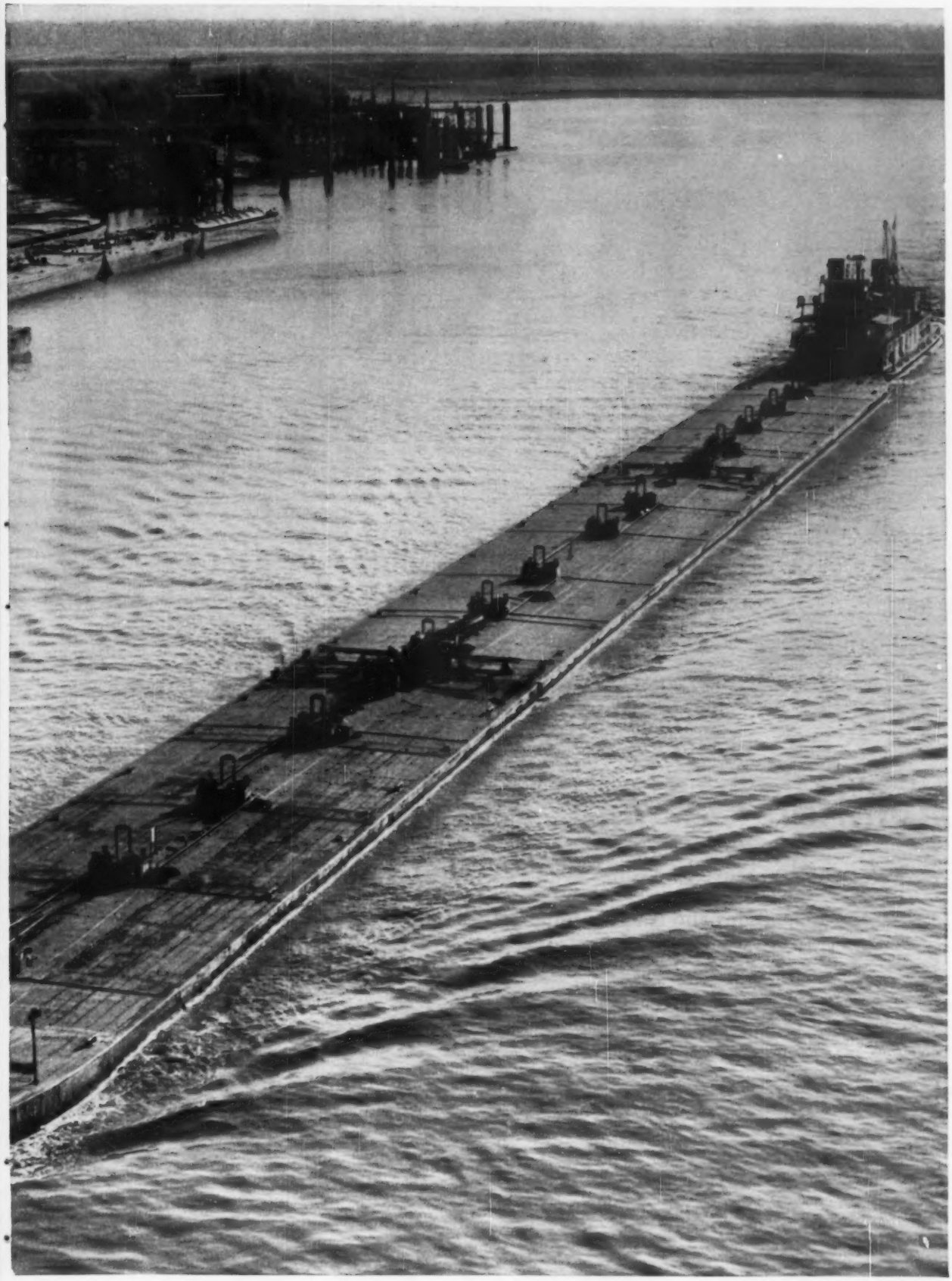
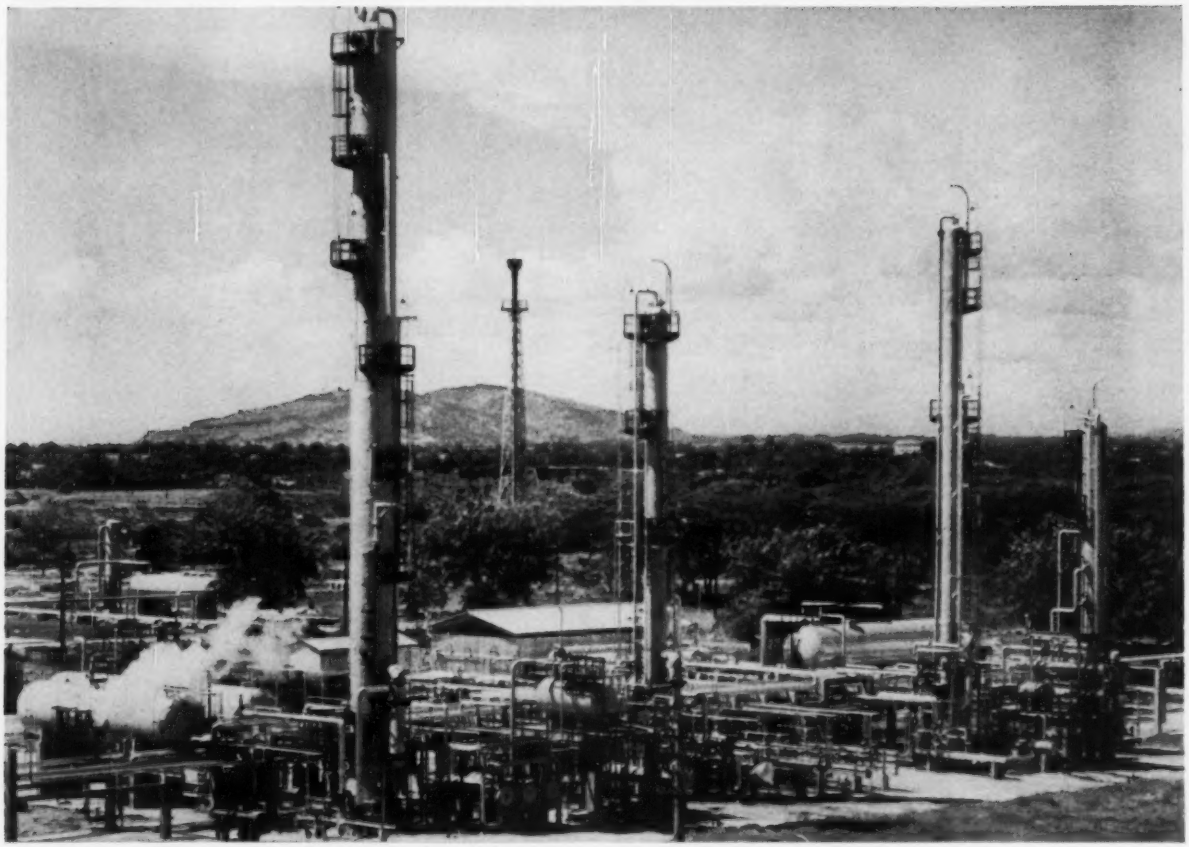
110 NORTH WACKER DRIVE • CHICAGO 6, ILLINOIS

For more data on advertised products, use Readers' Service Cards, last page.



For more data on advertised products, use Readers' Service Cards, last page.

Who's Building...



Chinese Petroleum Co.'s Avgas plant will produce 900 bpsd of alkylate.

Aviation Gasoline Plant for Formosa

New 35,000-bpd Kaohsiung refinery consists of sulfuric-acid unit and fractionating facilities

As the latest addition to its modern 35,000-bpd refinery at Kaohsiung, Taiwan (Formosa), Chinese Petroleum Corp. has put on stream a new aviation gasoline plant engineered by Badger Manufacturing Co.

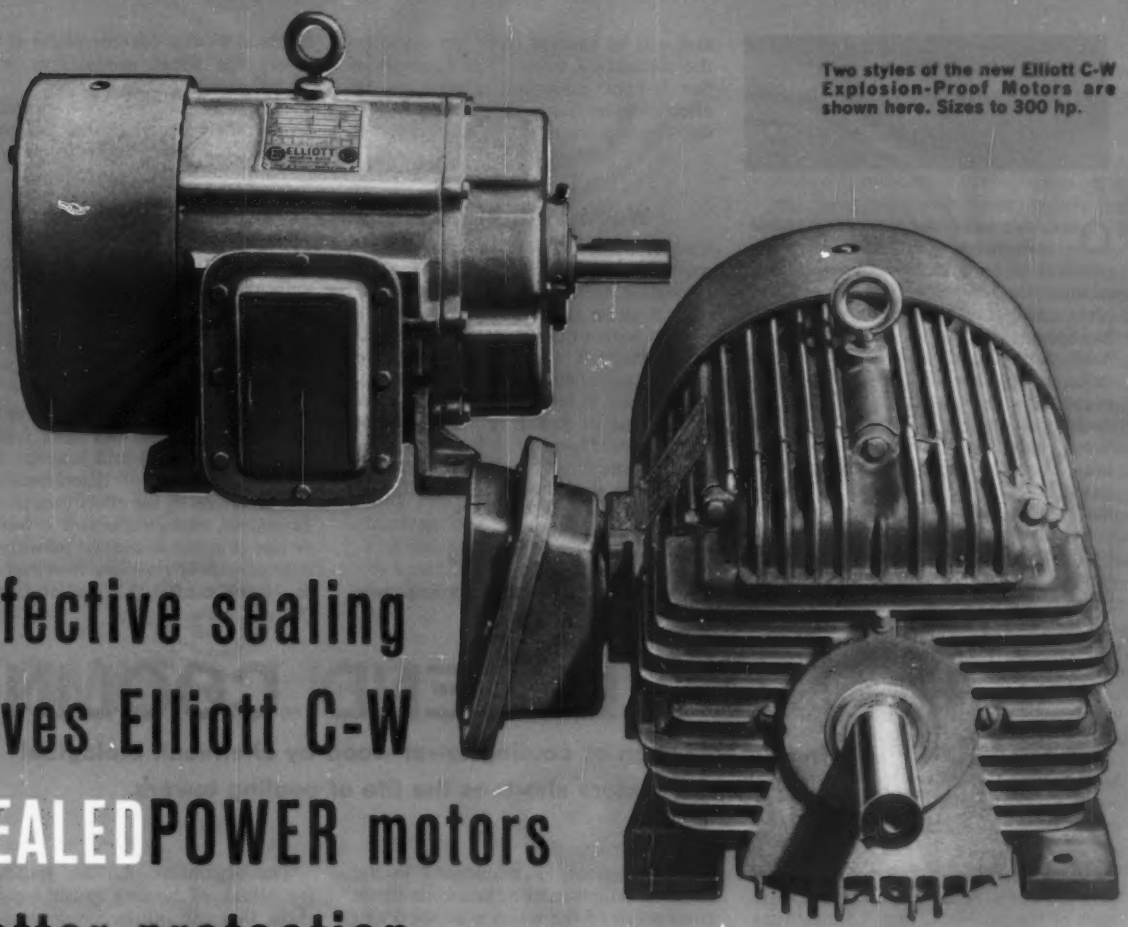
The plant, with a design capacity of 900 bpsd of alkylate, utilizes the process developed by Texaco Development Co. and others for converting butylenes and propylenes, together with isobutane from the refining operations, into alkylates of high-octane blending value. Design consists essentially of a sulfuric-acid-alkylation processing unit plus extensive fractionating facilities for high purity products and recycled fractions. A special contactor is employed for the low temperature intimate mixing of sulfuric acid with the hydrocarbon feed stock.

Initial runs, made at widely varying capacities and with several different compositions of charging stocks, are shown in the table of operating results.

The plant was designed and engineered at Badger's Cambridge, Mass., office. While certain detailing and fabrication was done in Taiwan, most equipment was supplied by vendors in the United States or, in some cases,

TABLE OF OPERATING RESULTS

Normal Design	Guarantee	Test Run
F-3 Performance No. +4.6 cc T.E.L.	120	134
F-4 Performance No. +4.6 cc T.E.L.	147	159
Feed, Bbl. Alkylate/Bbl. Olefin	001.6	001.6
Acid Consumption, Lbs./Gal. Alkylate	001.2	000.75
Maximum Capacity, bpsd	900	994

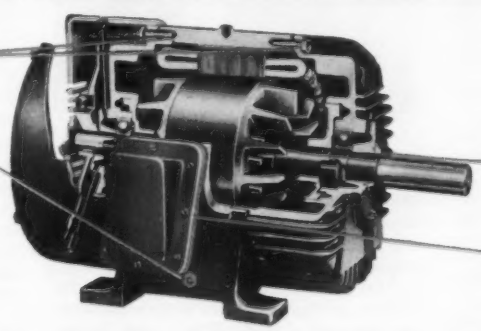


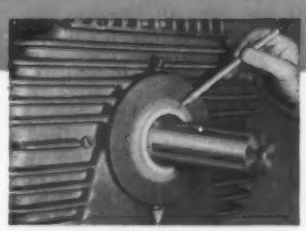
Two styles of the new Elliott C-W Explosion-Proof Motors are shown here. Sizes to 300 hp.

effective sealing gives Elliott C-W SEALEDPOWER motors better protection against moisture, dust, fumes, corrosion

LONG, SNUG BRACKET SEAL. Close-fitting, deep rabbet provides explosion-proof type seal for all SEALEDPOWER motors.

EASILY ACCESSIBLE, automatic breather and drain plug, underwriters approved, for removing internal moisture accumulations.



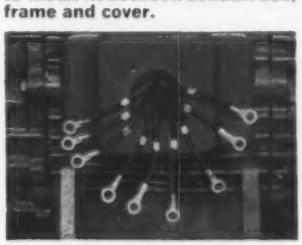


ROTATING SLINGER PREVENTS entrance of dirt and moisture through the bearing and shaft opening.

NO LEAKAGE HERE. Tightly sealed leads and opening. Metal-to-metal fit between conduit box, frame and cover.

NEW DATA on the complete line of Elliott C-W SEALEDPOWER motors is given in Elliott Bulletin PB 6000-2. Send for free copy today.

Elliott explosion-proof motor—underwriters approved.



ELLIOTT Company

Crocker-Wheeler Plant Jeannette, Pa.

HELPFUL WATER CONDITIONING DATA FROM BETZ

HOW TO EXTEND COOLING

■ The deterioration of cooling tower wood by chemical, biological and physical factors shortens the life of cooling towers.

OVER THE PAST DECADE considerable attention has been focused on the problem of cooling tower wood deterioration—and for good reasons. Complete collapse of some cooling towers has occurred. In other cases, fan supports have deteriorated, and the fans have fallen through the tower. Accidents have occurred due to collapse of ladders, decking and other parts of the tower. Wood deterioration has shortened the life of cooling towers from the anticipated 20-25 years to 10 years or less in many cases. Repairs and replacement costs have been excessive, and cooling tower operation has been inefficient. During the past decade, many organizations have been engaged in a study of the problem to determine the causes and possible cures. Since water is an intimate part of the problem, Betz Laboratories is actively engaged in the study of wood deterioration.

Cooling Tower Wood Composition

Redwood is the most commonly used material for cooling tower construction. It has been in use for this purpose almost since the advent of cooling towers themselves. Originally, this material was selected because of high strength to weight ratio, ready availability, ease of fabrication, cost and natural resistance to decay. Other species are used for this purpose, particularly Douglas Fir and less frequently cypress and pine.

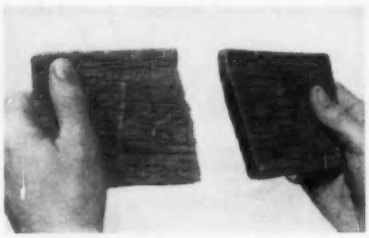
Wood is composed of three main components; cellulose, lignin and natural extractives. The cellulose exists as long fibers almost identical to cotton fibers, and gives wood its strength. The lignin acts as the cementing agent for the cellulose. The extractives contain most of the natural compounds which contribute to the resistance to decay. In general, the more highly colored woods are the more durable. A typical analysis of redwood, based on the dry weight, will show approximately 50% cellulose and hemi-cellulose, 30% lignin and 20% extractives. The extractives present in redwood make this material one of the most resistant to decay. Unfortunately, the extractives present in all woods are largely water soluble, and will be leached from the wood by the circulating water. The strength of the lumber does not appear to be affected by leaching. However, the wood does become more susceptible to decay.

Types of Wood Deterioration

Cooling tower wood is subject to three main types of deterioration; chemical, biological, and physical. It is rare where one of these types of deterioration is present without the other. In most cases these different types of deterioration occur simultaneously. When deterioration occurs it is difficult to determine which type of attack is predominately responsible. However, it is evident that physical and chemical deterioration will render the wood more susceptible to biological attack.

Chemical Attack

Chemical deterioration of cooling tower wood commonly is manifested in the form of delignification. Since the lignin component of the wood is affected and removed by this type attack, the resultant residue is rich in cellulose. The chemicals most commonly responsible are oxidizing agents such as chlorine, and alkaline materials such as sodium bicarbonate and sodium carbonate. *The attack is particularly severe when the combination of high chlorine residuals and high alkalinity concentrations are maintained simultaneously.*



Brash, checked wood.

Typically the wood takes on a white or bleached appearance, and the surface becomes fibrillated. This attack is restricted to the surface of the wood and the strength of the unaffected area is not impaired. However, severe thinning of the wood will occur wherever cascading water has an opportunity to wash away the surface fibers. In serious cases, the loosened fibers have caused plugging of the screens and tubes, and have served as focal points for corrosion at areas where the fibers accumulate in heat exchange equipment.

Chemical attack most frequently occurs in the fill section and flooded portions of the tower where water contact is continuous. However, it will occur also in those areas where alternately wet and dry conditions develop—such as on the air intake louvers and other exterior surfaces. Chemical attack occurs also in the warm, moist areas of the plenum chamber of the tower caused by chlorine vapors and entrainment of droplets of tower water.

Biological Attack

Biological attack of cooling tower wood can be divided into two basic types . . . soft or surface rot and internal decay. These two types of deterioration are characterized by the effect they produce. *In general, biological attack is insidious. It can proceed relatively unnoticed for long periods of time and then can manifest itself suddenly . . . and disastrously.*

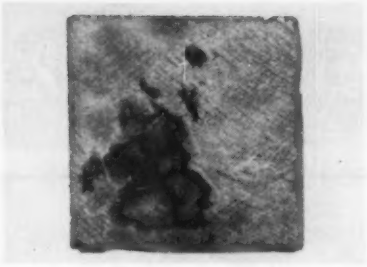
The organisms that are responsible for attack of cooling tower wood are those that can utilize cellulose as their source of carbon in their growth and development. Degradation of the cellulose is accomplished by the secretion of enzymes which convert the cellulose into compounds that can be absorbed by the organisms. The attack tends to deplete the cellulose content of the wood and leaves a residue rich in lignin. Characteristically, the wood becomes dark in color and loses much of its strength. The wood also may become brash, soft, punky, cross-checked or fibrillated. The principal cellulolytic organisms isolated from cooling tower wood are primarily fungi, which include the classical wood destroyers (Basidiomycetes), and members of Fungi Imperfecti. However, bacterial organisms that exhibit cellulolytic properties also have been isolated but their exact role in cooling tower wood deterioration is yet to be determined. The wood destroying organisms are common air and water borne contaminants, and are widely distributed in nature.

The classical *internal decay* is restricted generally to the plenum areas of the tower, such as the cell partitions, doors, drift eliminators, decks, fan housing and supports. It is the more insidious of the two types of biological attack. It is characterized externally by an apparently sound piece of wood, which upon breaking shows severe in-

ternal decay. Because the decay is internal, it is difficult to detect in its early stages. Rarely is internal decay found in the flooded portions of the tower such as the fill section. In these sections, the wood is saturated completely with water which excludes oxygen from the interior of the wood. The absence of oxygen limits the growth and development of these organisms.

Soft or surface rot is found predominantly in the flooded sections of the tower but also occurs in the plenum areas. The water flowing over the wood surfaces in the flooded portions contains enough oxygen to support growth. Surface rot is detected more readily, and its effect is less severe than internal decay.

In addition to oxygen—moisture and temperature have a marked bearing. Locations where the moisture content of the wood range between 20 and 27% and temperatures range between 88 and 105 F, usually permit optimum growth and development of the organisms.



Internal biological attack.

Chemical deterioration as manifested by delignification can be controlled readily by restricting the pH and chlorine concentration of the circulating water. It is advisable to restrict the pH below 8.0 and preferably in the range of 6.0-7.0. In this range, the alkaline salts will be at a low level, the rate of leaching of extractives will be slower and the adverse effect of chlorine will be lower. It is also advisable to restrict the free chlorine residual to no more than 1.0 ppm, or preferably lower. Intermittent chlorination is preferred over continuous chlorination, since the latter even at concentrations less than 1.0 ppm tends to promote more rapid deterioration of tower wood.

Biological deterioration of the surface type, particularly in the flooded portions of the tower, can be greatly minimized by the same factors which minimize chemical attack. There is ample evidence that chemical surface attack renders the wood more susceptible to biological surface attack. In addition to the control of pH and the judicious use of chlorine, the supplemental periodic addition of non-oxidizing biocides to the circulating water to control the causal organisms will be of material benefit.

The control of biological deterioration in the plenum areas of the tower is considerably more complicated, primarily because of the internal decay which is prevalent in these areas. *This type attack can proceed relatively unnoticed for long periods of time and then can manifest itself suddenly—and disastrously.* This statement is repeated to emphasize the insidious nature of this type attack. Thorough inspections will not always disclose the extent or presence of incipient decay. Detection is made generally only after extensive damage has been done. Infected members should be removed and replaced preferably with 'treated' lumber. Because of the random nature of the attack, and the fact that only the most seriously affected areas will be discovered and replaced, subsequent discovery of more areas of infected lumber will be uncovered with time, and maintenance and repair costs will mount.

The existing methods of control of biological deterioration in the plenum areas of operating towers involves spraying the lumber with preservatives that are toxic to the causal organisms. Impregnation of the wood relies on diffusion of the toxicants into the wood. Whereas diffusion of the toxicants through the ends of the wood members is good, diffusion across the grain is not very great, often limited to penetration of the outer ⅛" to ¼" of the member. In large members, where the internal rot is deeply seated, the toxicant will not reach the infected area and growth of the organisms can continue. Accordingly, at best the procedure of spraying the plenum areas of the tower can only help in containing the infection. *Because of this limitation it is essential that the corrective procedure be applied before the tower is seriously infected.* Therefore, for maximum benefit in minimizing biological attack of the internal type, spraying of the plenum areas of the tower should be done before serious infection has developed. The spray procedure should be adopted and viewed as preventive maintenance.

In order that serious attack be avoided, periodic examination of the tower should be augmented by submitting wood samples to a qualified microbiological laboratory. Studies of the wood can be made which will show the incidence of fungi on the surfaces and interior sections of the wood and whether cellulolytic organisms were or are present. The natural resistance of the wood should be checked to determine whether it has diminished to a point where it is no longer effective against microbiological attack. These studies can serve as a basis for determining when to initiate the preventive spraying program.

TOWER LIFE

Physical and Other Factors

One of the major physical factors is the effect of temperature upon wood. Wood technologists have long recognized that high temperatures have an adverse effect on wood. It is known that continuous exposure to high temperatures will produce gross changes in anatomical structure and will accelerate loss in wood substance. These resultant effects will weaken the wood and predispose it to biological attack particularly in the plenum areas of the tower.

There are other factors which also have a bearing on the deterioration of tower wood. For example, areas adjacent to iron nails and other iron hardware usually deteriorate at an accelerated rate. These areas invariably lose much of their strength and the wood will crumble easily in the fingers. Slime and algae growths and deposition of dust and oil can all aid the growth and development of the soft rot organisms.

Control of Wood Deterioration

While the subject of wood deterioration under cooling tower operating conditions is far from being completely understood, a considerably better understanding of the process has been gained during the last few years. With this understanding, a comprehensive program can be outlined which, if followed, will assure a minimum of attack and longer tower life.

Betz Laboratories maintain a well equipped microbiological laboratory, staffed by microbiologists with an extensive background in the field of cooling tower wood deterioration. We will be pleased to make our facilities and services available for the study of your cooling tower problems. For more details on the care and maintenance of cooling tower wood deterioration, write for Bulletin 605.

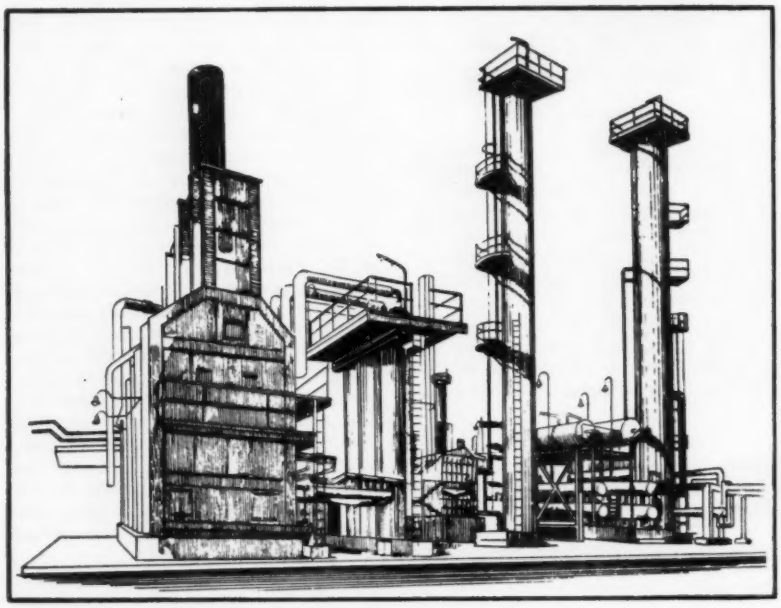
BETZ LABORATORIES, INC.
Gillingham & Worth Streets • Phila. 24, Pa.

■ CONSULTANTS ON INDUSTRIAL WATER PROBLEMS

Building . . .

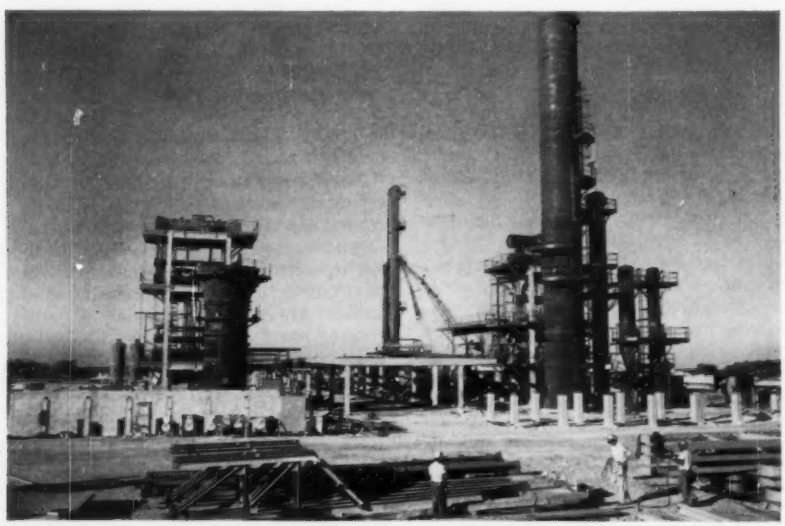
was fabricated in Europe under direction of Badger's international organization.

Construction of the plant was completed on schedule by Chinese Petroleum's own staff, assisted by Badger. Concurrent with the enginering and construction phases, Badger trained CPC engineers to operate and maintain the plant.



Abadan Refinery to Get Big Cat Cracker

National Iranian Oil Co. is planning a major addition to facilities at its Abadan refinery. The company will build a 20,000-bpd cat cracker to produce high-octane components essential for premium-quality gasoline. To cost approximately $9.7 million, the project's design and construction is expected to take about two years.



StanCal Expands Its New Hawaiian Plant

Standard Oil Co. of Calif.'s Western Operations, Inc. has started further expansion of its 32,000-bpd Hawaiian refinery, being built near Honolulu. New equipment, supplementing that already under construction, will include a 13,000-bpd fluid catalytic cracker and alkylation plant for manufacture of high octane gasolines and aviation fuels. Also included will be hydrogenation and isomerization units for processing specialized products and feed stocks; a carbon monoxide boiler, dust precipitator and sulfur recovery equipment to assure complete pollution controls; additional tankage for storage of products and crude oil, and numerous other utilities.

Erection of these new facilities will provide the Mid-Pacific area with its "first complete petroleum processing plant" and will nearly double the company's original investment of about $33 million in the Hawaiian refinery.

Construction of a crude still, treating plants, pipelines, tanks, marine loading facilities and laboratory-office buildings has been underway for over a year at the 300-acre Barber's Point site and will be completed by October 1960. The additional equipment is expected to be on stream by the middle of 1962. At the new plant, Standard will manufacture 21 finished products, including three grades of motor gasoline, four grades of aviation gasoline, two of jet fuels, two of light diesel fuels, four each of asphalt and heavy fuel oils, a supply of liquefied petroleum gas and a special weed-killer oil.

Dow Chemical Co. is planning a $30-million expansion program at Plaquemine, La. Included will be a plant for the production of ammonia, increases in production capacity for chlorine, caustic soda and vinyl chloride, and additions to power and steam generating facilities. The expansion will take place over the next two years. Construction will begin at once with completion and start-up scheduled for late 1961 and early 1962.

The company already has an expansion project in progress at Plaquemine, involving an investment of about $12 million. A high-pressure polyethylene plant, a major part of the current work, is scheduled for operation this fall. When completed, the new expansion project will bring Dow's total investment at Plaquemine to more than $100 million. The new ammonia plant will make both anhydrous and aqueous ammonia. Construction of other major plants at Plaquemine was completed in mid-1958. They include facilities for light hydrocarbons, chlorinated solvents, and oxides and glycols of ethylene and propylene, in addition to vinyl chloride, chlorine, caustic soda and power.

Bay Petroleum Co. plans an entry into the petrochemical field. The initial step will be construction of a 2,000-bpd aromatics unit at its Chalmette, La., refinery. The unit will include facilities for production of a full line of aromatic solvents, including benzene, toluene, xylenes and heavier aromatics. Construction will begin around mid-year, with completion expected in the spring of 1961. A construction contract has not been let. To be installed are a catalytic reforming unit, an aromatic extraction plant and facilities for distillation and separation of individual aromatics.

Construction of the aromatics unit will follow a product improvement and facilities modernization program nearing com-

what's your best estimate?

. . . a quiz for refinery men who want to keep posted

QUESTION 1. In these countries in the sterling area—England, Scotland, Ireland and India—how many new oil refineries have been built since the close of World War II?

a 4

b 6

c 8

d 12

QUESTION 2. How many of these refineries have been designed, engineered and constructed by Lummus?

a 3

b 5

c 7

d 9

ANSWERS: 1. *The answer is* (d)—*12 new refineries since the war, according to* World Petroleum *magazine.*

2. *Here* (b) *is correct. Lummus has built 5, or 42%, of the new refineries in these countries since World War II, through the Lummus Company Ltd. of London. These five refineries are for Vacuum Oil Company Limited at Corylon, England; California Texas Oil Corporation at Vadakhapinam, India; Burmah-Shell Refineries, Ltd. at Bombay, India; Standard-Vacuum Oil Company, Ltd. at Bombay, India; and the Irish Refining Company, Ltd. at Whitegate, Ireland. Lummus Ltd. maintains a staff of over 400 specialists, and has engineered and constructed hundreds of process plants of all types and sizes in the sterling area from India to Ireland. Lummus Ltd. is one of seven international members of the Lummus group of companies which circles the globe. See Lummus on your next project.*

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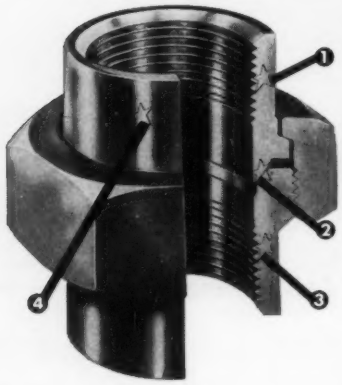

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3. More than adequate wall thicknesses give you Catawissa's 3-to-1 Safety Factor (3000-lb. service, 9000-lb. test; 6000-lb. service, 18000-lb. test)!

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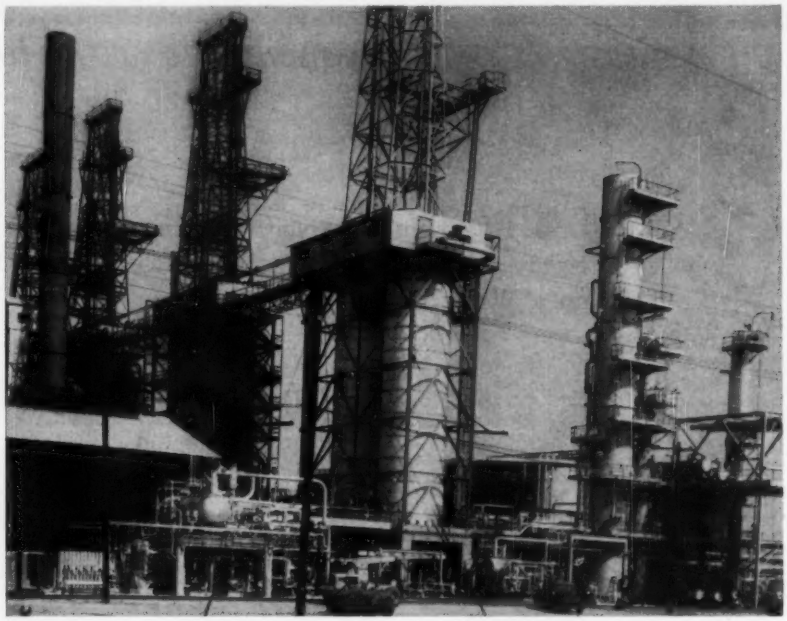
Building . . .

pletion at the refinery. This work has included installation of a new 35,000-bpd crude unit and a 2,700-bpd alkylation unit; revamping of the plant's catalytic cracking unit to increase its capacity by more than 50 percent, to approximately 15,000 bpd, and the addition of approximately 200,000 barrels of storage capacity.



Delayed Coking Unit for Torrance Plant

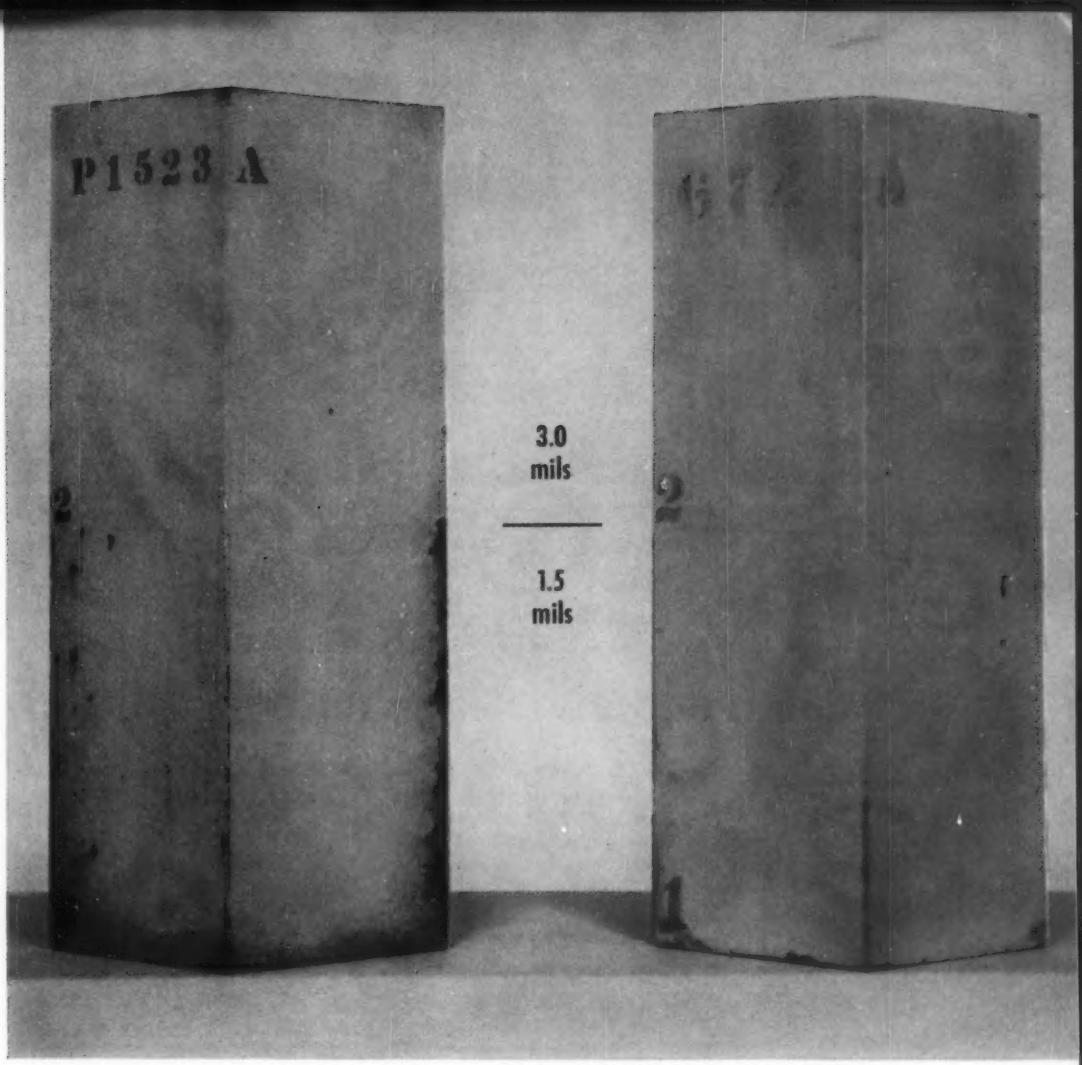
Mobil Oil Co. has completed a new delayed coking unit, giving its Torrance, Calif., refinery one of the largest such installations in the world. The new unit, with a throughput of 9,300 bpd, increases Torrance coking capacity to 35,000 pbd, equal to the entire throughput of many refineries. The new coking facilities, constructed by Bechtel Corp., cost upwards of $4.5 million. Mobil Oil officials explained that the new installation is particularly useful to the Torrance refinery because much of the crude supply is low gravity heavy oil. The delayed coking operation helps make salable products such as gasoline and solid petroleum coke out of the low-value "ends" of the crude oil barrel.

Witfield Chemical Corp. has been formed by Richfield Oil Corp. and Witco Chemical Co., Inc. The new company plans to construct and operate a $1.75-million petrochemical plant for the production of dodecylbenzene, a basic raw material used in the manufacture of detergents. The plant will be located adjacent to Richfield's Watson refinery, Los Angeles. The contract for its construction will be awarded in the near future. Present plans call for completion early next year. Richfield will supply raw materials for the new operation—namely, benzene and propylene tetramer; and Witco will assume responsibility for marketing the plant's output.

Columbian Carbon Co. will construct a plant for the manufacture of carbon black in Canada to meet the growing requirements of Canadian consumers. To be located in the Toronto area, the facility is expected to begin operations in 1961 with an initial annual capacity of approximately 40 million pounds of oil furnace blacks. The plant will be operated by Columbian Carbon (Canada) Ltd.

Phillips Chemical Co. will further expand ethylene capacity by constructing a new plant adjacent to its existing ethylene plant at Sweeny, Texas. Capacity of Phillips' present plant is being raised to 290 million pounds annually by an enlargement which will be completed in the second quarter of 1960. The new plant will nearly double this capacity when it is completed in the third quarter of 1961. Part of the ethylene produced at Sweeny is used to make Phillips linear polyolefin plastics at a plant on the Houston Ship Channel. Preliminary engineering work for the new plant is under way and bids are being received for construction contracts.

Susquehanna-Western, Inc. has placed into operation a new sulfuric acid plant at Riverton, Wyo., doubling the company's production capacity of the product. The new unit, second sulfuric acid plant to be operated by the company, expands production capacity to 75,000 tons of acid per year. Susquehanna-Western, launched its sulfuric acid operations in December 1958, with the completion of Wyoming's first commer-



Never before such durable protection, never before such lasting appearance in metal protective paints.

Proof anti-corrosion finish paints made with M50® pigment give unique freedom from bilging

Compare ... for color ... the gray alkyd finishes on the two exposure test angles shown above.

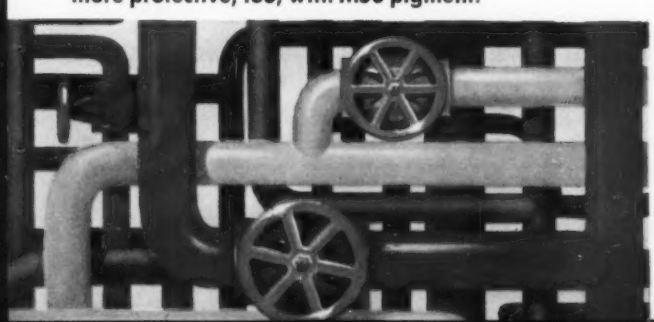
By all previous concepts for anti-corrosion paints, the one on the left should be the darker, should show some splotchiness . . . even though the paint on both angles came out of the same can. That's because the angle on the left was exposed (four years, 45°S) to the heavily sulfur-laden industrial atmosphere of Perth Amboy, N. J., while the angle on the right was exposed (four years, 45°S) only to the normal atmosphere found at National Lead's Sayville, L. I. Test Station.

As you can see, the color difference . . . bilging . . . that you might expect from SO_2-caused precipitation simply has not developed in this paint made with *M50* pigment.

Combined with its unique resistance to discoloration by the chemicals found in industrial atmospheres, fused M50 basic lead silico chromate pigment demonstrates exceptional rust inhibitive action.

Now, with *M50* pigment, your regular paint suppliers can provide standard or deep-coat anti-corrosion primers, intermediates and finishes with superior rust inhibition, superior weather resistance, and excellent tintability. Paints that are more durable and don't bilge. The *M50* pigment is suitable for use with a wide variety of vehicles.

Color code paints look better longer, are more protective, too, with M50 pigment.



See, on the next page, more details... and how you can get these new, much more durable anti-corrosion paints.

M50 an **oncor** *pigment development of*

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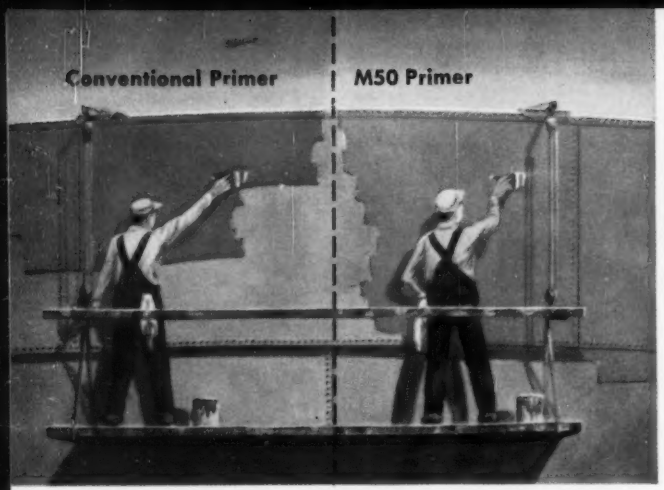
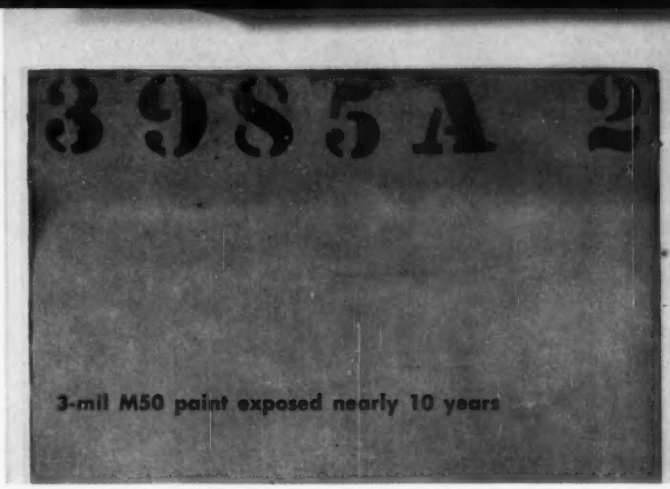


Weight for weight, anti-corrosion paints made with high-bulking M50 pigment cover 40% to 60% more steel.



Mil for mil, M50 paint films show better rust-inhibitive performance, lengthen the painting cycle interval.

Here's evidence M50 pigment paints reduce anti-corrosion maintenance painting costs two ways

On the preceding page you have seen evidence that *M50* pigment paints are unique among anti-corrosion paints for anti-bilging properties. Exposure tests at National Lead's Sayville, L. I. Test Station have demonstrated these metal-protective paints are also unique for their anti-corrosion action, their weather-resistance, their color stability and many other performance characteristics.

Above you see evidence that *M50* pigment paints are equally unique in their ability to provide anti-corrosion maintenance painting economy. The illustration at left gives you a visual comparison between the coverage of a conventional anti-corrosion primer and an equal weight of an *M50* counterpart of this same primer (Fed. Spec. TT-P-86a, Type I). Clearly a given weight of *M50* pigment paint goes further.

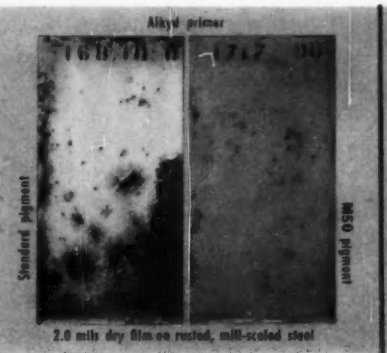
The picture at the right shows the condition of a 3-mil *M50* pigment *primer* exposed nearly 10 years *without a finish coat.* You can see that even in this severe test . . . an unprotected primer . . . anti-corrosion action is still being obtained. The repainting surface is still in good shape. Weather has not adversely affected protection. Imagine how many years of service you can anticipate from anti-corrosion *M50* finish coats applied over anti-corrosion *M50* primers in the normal or deep-coat systems!

Based on cost per sq ft per year, M50 pigment paints can greatly reduce the cost of your anti-corrosion maintenance painting.

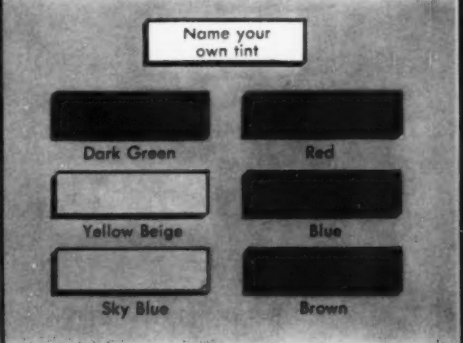
Why M50 Defense in Depth paints give anti-corrosion beyond all former concepts

2 standard pigment alkyd primer coats
1 standard pigment alkyd primer coat
Gray Alkyd Finish Coat
2 M50 pigment alkyd primer coats
1 M50 pigment alkyd primer coat

Exposed 9 years, 45°S. Each coat 1.5 mils
Proved corrosion and weather resistance



Exposed 45°S; 1 yr ind. atmos, 1 yr normal atmos.
Proved outstanding for film strength, durability



Colors above available in conventional and heavy-coat paints
A wide range of stable colors can be produced

Are you concerned with tank or structure maintenance painting in your firm? If so, you are invited: (1) to visit National Lead's Sayville, L.I. test station, where you will see the results of the 20 years research that lies behind the *M50* pigment particle and the more than 10 years of exposure testing that lies behind *M50* pigment Defense in Depth paints; (2) to send coupon below for National Lead booklet, "Defense in Depth" and typical *M50* tank paint specifications.

Next time you purchase, specify *M50* pigment paints. Any paint manufacturer can supply you.

M50 Defense in Depth

National Lead Company,
111 Broadway, New York 6, N. Y.

ancor TRADEMARK

Gentlemen: Please send me the "Defense in Depth" booklet together with typical tank paint formulas and color chips that I can use in specifying M50-type tank paints.

Name_____ Title_____

Firm or Dept._____

Address_____

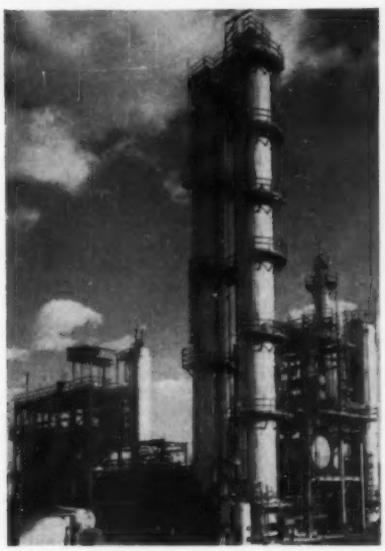
City_____ State_____

Building . . .

cial sulfuric acid plant, also at Riverton. The company is Wyoming's only sulfuric acid producer. Constructed by Susquehanna Engineering Co. in four months, the plant utilizes the most technically advanced processes, and is fully automated. Acid is produced through the burning of pure sulfur and conversion of the resulting gases. Sulfur for the plant is obtained from local Wyoming suppliers who recover it from sour natural gas.

Giant Propylene Plant Is Completed by Sun Oil Co.

Sun Oil Co. has placed into operation a new $2-million propylene plant, said to be the largest in the United States, at Marcus Hook, Pa. Designed to produce the high-priority propylene required by



polypropylene manufacturers, the new Sun plant produces a material with a purity of 99.9 percent from refinery gas streams. Currently, production of the plant is being supplied to AviSun Corp. for the manufacture of polypropylene resin, packaging films, fibers and molded products. Sun's plant is designed for a potential capacity of 120 million pounds a year of high-purity propylene. Two distillation towers, with a combined total of 140 fractionating trays, comprise the major equipment in the new plant. Each tower is 145 feet high, 10 feet in diameter, and weighs approximately 200 tons. They were fabricated by Sun Shipbuilding and Dry Dock Co.

Italy is considering construction and expansion of several refineries. The Interministerial Committee on Petroleum Industry Regulation plans a new petrochemical plant at Brindisi and a SAICA refinery at Porto Torres in Sardinia. Expansions would include the SAROM plant, Ravenna; Garrone refinery, Genoa; Purfina plant, Milan; Volpato plant, Milan; and the Sicedison petrochemical plant in Mantova.

British Petroleum Co. is planning to build a new 10,000-bpd cat cracking unit at its Dinslaken, West Germany, refinery, which is nearing completion (see January 1960 issue, page 202). The new cat cracker will produce high-octane components for premium-grade gasoline. To provide feedstock for the installation, a vacuum distillation unit will also be constructed. Another part of this additional project is a 100,000-ton-per-year bitumen plant which will process heavy residue from the vacuum unit. Design work has begun on these units, and the cat cracker is slated to come on stream in mid 1961.

Columbia-Southern Chemical Corp. has begun construction of an ethylene dichloride plant at its Lake Charles, La., facility. The plant will cost more than $1 million and initial production is scheduled for September 1960. The new unit will adjoin the firm's large chlorine and caustic soda manufacturing operation. Production of this organic compound will mark Columbia-Southern's entry into chemicals based on ethylene. It will be the first captive use of chlorine produced at the Lake Charles location. The process for the new plant was developed by the Research and Development Department at Columbia-Southern's Corpus Christi operation. Extensive pilot

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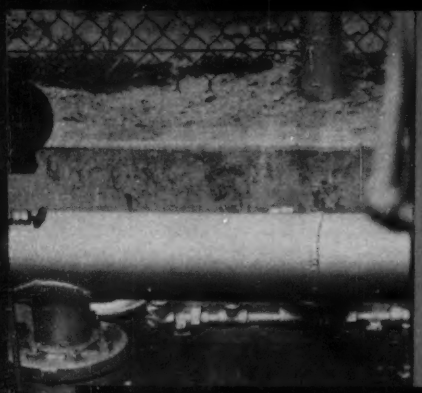

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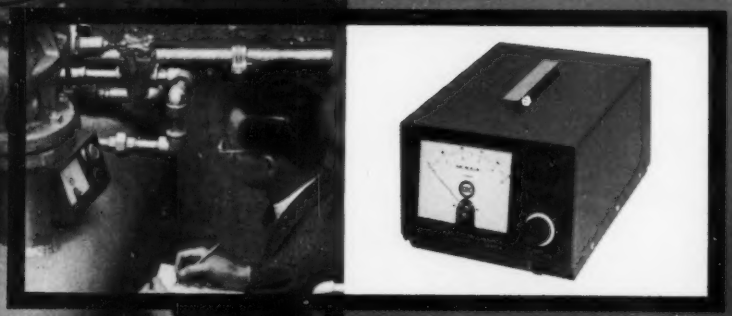

Plagued with water contamination? CEC's complete line of Moisture Monitors makes possible continuous safeguarding of both gas and liquid streams—instruments accurately and reliably measure trace moisture to less than one part per million water by volume.

PORTABLE MOISTURE MONITORS
are suitable for laboratory or field use. They can be used with or without line power, provide continuous readout on a large front-panel meter. For further information contact your nearby CEC sales and service office, or write for Bulletin CEC 1834-X4.

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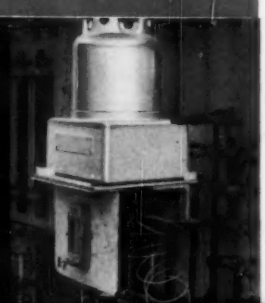
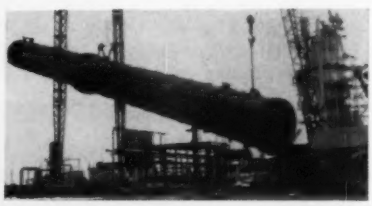


Building . . .

plant testing on the new process also was completed at the Corpus Christi plant. Petroleum Chemicals, Inc.'s Lake Charles plant is about three miles from Columbia Southern's operation, and ethylene will be delivered through a pipe line.

Iso-Stripper Tower Being Installed at Clarkson Unit

Slender "gin-poles" 100 feet high support the 130-ton weight of a 154-foot iso-stripper tower being installed at British American Oil Co.'s Clarkson refinery near



Toronto, Ont. One of the tallest processing vessels at any oil refinery in Canada, the tower is part of an alkylation unit being built to increase production of high octane gasoline at the refinery. The 12-foot diameter tower was fabricated in three sections by Toronto Iron Works and welded together prior to raising by Procon (Canada) Ltd.

Sunray Mid-Continent Oil Co. has started a $900,000 expansion program at two of its Gulf Coast Division gas products plants. In Jackson County, Texas, the Carancahua Bay plant will be expanded at a cost of $400,000. The plant began operation in 1959 and was originally designed to process 30 MMcf of gas a day. After the expansion, capacity will be doubled to 60 MMcf. At Sunray's Benton plant, Bossier Parish, La., $500,000 will be spent to increase propane recovery and produce higher-quality residual products. Constructed in 1947, Benton was originally designed as a cycling plant and functioned as such until January 1960, when gas-sales contracts were signed. Both units are to be completed and in operation by early summer. Over-all management of the two projects is being handled by Sunray's engineering staff. Early in March, Sunray announced a $750,000 expansion at the Criner gas products plant, McClain County, Okla.

Humphreys & Glasgow, Ltd. and **Petrocarbon Developments, Ltd.,** will build a 40,000-ton-per-year ethylene plant in East Germany. The order for design and engineering of the project's first phase was signed in January by representatives of the East German Foreign Trade Enterprise "Dia-Chemieausrustungen" and the British companies, and work will begin soon. The first phase is due for completion in December 1962. The plant marks the first time that British companies have provided both engineering and design for an installation of this

type outside the United Kingdom. It is also the first time that British companies have obtained a contract for a complete chemical plant for East Germany, whose chemical industry ranks second, among the Eastern countries, only to that of the Soviet Union.

Imperial Chemical Industries, Ltd. has decided to start building the first plants on its thousand-acre site in South Gloucestershire, near Avonmouth, England. Construction work will begin this spring, and the plants are to start production in about two years. The first stage of construction on the site, to be known as Severnside works, will involve spending about $13 million. This will cover initial site development and the construction of plants for making 35,000 tons per year of ethylene oxide, ethylene glycol and associated products. Ethylene will be supplied by Esso Petroleum Co., Ltd. Ethylene oxide will be made by Scientific Design Co.'s air oxidation process. SD will also design the plant, while plants for ethylene glycol and associated products will be designed by ICI.

Continental Oil Co. is constructing a 200,000-barrel underground cavern in Ponca City, Okla., for propane storage, at a cost of $1.27 million. The cavern, to be mined in a limestone formation 350 feet underground, will be completed early in 1961. A shaft four feet in diameter will be drilled to the cavern level, cased and cemented. After manually excavating a small room at the 350-foot level, dismantled mining machinery will be lowered and re-assembled to rush the project to completion. The cavern will consist of a series of connecting tunnels about 20 feet in height and extending out from the central shaft.

Refineria Panama, S.A., a Panamanian corporation, plans to construct a $30-million refinery in the Republic of Panama. It would be the first refinery built in Central America. Refineria Panama will be owned jointly by a subsidiary of Continental Oil Co. and interests of National Bulk Carriers, Inc. Permission to construct the project was granted Refineria Panama by the Panamanian government. The plant will be located on Payardi Island near Colon at the Carribbean Sea entrance to the Panama Canal. Completion is scheduled by early 1962. A contract to build the refinery will be awarded shortly.

DX Sunray Oil Co. has started a double-barreled modernization program costing $1.6 million, at Duncan, Okla. The two projects involve:

- Installation of a new steam generator and complete turnaround of the catalytic cracking unit at a cost of $600,000.
- A $1-million modernization of the gas recovery unit.

Structural work on the new generator has begun. It will replace a flue gas generator and a Cottrell precipitator. The new generator will be capable of generating 60,000 pounds of steam per hour at a pressure of 175 psi. Waste heat from the unit will be used in the process. Assembly and installation work is being

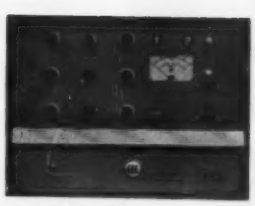
STEALS THE SHOW

in closed-loop process control

First at the ISA meeting in Houston, again in Pittsburgh – CEC's new 26-212 Process Chromatograph stole the shows.

Why? **Because its modular design means that buyers now can choose from among the most advanced chromatographic features, yet buy only what they need. Among its design options: high speed, multiple columns, precutting, back flushing, continuous variable attenuation, and multiple stream switching.**

Why else? **Because the 26-212's high speed makes it ideally suited to automatic, closed-loop process control. It's an instrument man's instrument, with plenty of room inside for adjustments, reprogramming and rebuilding for new applications . . . no valve lubrication, no preventive maintenance needed. Read all about the money-saving modular design of the 26-212 in Bulletin CEC 1860-X3.**



The new CEC process chromatograph's analyzer unit is housed in an explosion-proof container for installation in hazardous locations. The control unit can be located up to 500 feet from the analyzer. For more information about CEC process control, write for Bulletin 1859-X6.

Analytical & Control Division CEC

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TURNS...

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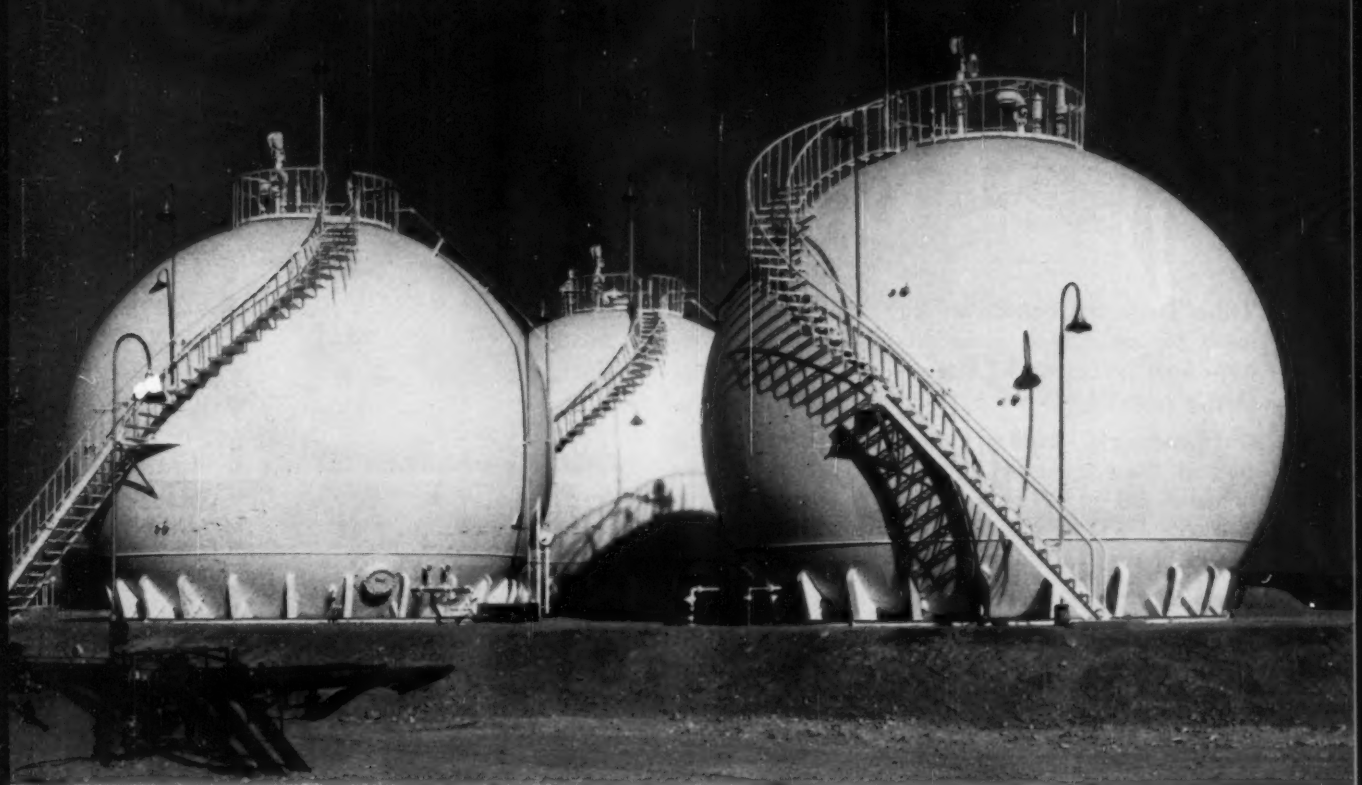
the natural way to store natural gasoline and stop evaporation loss



Hortonspheroids® are used to store liquids that are too volatile to hold at atmospheric pressure. They prevent breathing and boiling losses and reduce filling losses to a practical minimum. No vapor can be lost as long as the internal pressure does not exceed the settings of the pressure relief valves.

The three 3,500-bbl. Hortonspheroids above were erected for the storage of natural gasoline at the Texas Natural Gasoline Corporation, Perkin's Plant, Coke County, Texas. They are designed for 45 lbs. per sq. in. working pressure and were pickled and painted by the Horton® Pickling Process, an efficient means of removing mill scale from steel to provide a better bond between paint and metal.

Hortonspheroids are built in capacities to 120,000 bbls. and for pressures to 100 lbs. per sq. in. in smaller sizes. For further information please write our nearest office.

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Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PA.
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Horton Steel Works Limited, Toronto; Chicago Bridge & Iron Company Ltd., Caracas; Chicago Bridge Limited, London; Sociedade Chibridge de Construcoes Ltda., Rio de Janeiro.

Above: Three 3,500-bbl. Hortonspheroids, built by CB&I for the Texas Natural Gasoline Corporation, Perkin's Plant, Coke County, Texas. The structures are 35 ft. in diam. and were designed for a working pressure of 45 lbs. per sq. in.

CB&I

Building . . .

done by Procon, Inc. New equipment will be put into operation following the annual turn-around of the cat cracker. Completion is scheduled for May 15. Preliminary engineering studies have been started on the gas recovery unit, which will be completely revamped to increase recovery efficiency. The unit produces propane-propylenes and butane-butylenes. Construction work is slated to start September 1.

The Houston Chemical Corp., a subsidiary of Chatham Chemical Corp., New York, plans to build a $12-million ethylene glycol plant in Beaumont, Texas. The company has purchased 40 acres for the plant site, adjacent to the $25-million high-purity ethylene plant being built by Mobil Oil Co. The proposed plant, still in the engineering stages, will produce between 8 million and 12 million gallons of ethylene glycol a year. Construction is to start this year, with completion in about 16 months. Ethylene feedstock will come from Mobil's 380-million-pound-per-year ethylene-propylene-butadiene plant.

The American Oil Co. has completed erection of a coking unit at Texas City. The unit was dismantled at Destrehan, La., last summer, moved to Texas City, erected by Tellepsen Construction Co., and placed in operation last month. The coking unit will convert 10,600 barrels of reduced crude oil into 6,000 barrels of gas oil, and 2,300 barrels of gasoline every 24 hours. Amoco will shut down its No. 1 thermal cracking unit indefinitely because of "a buildup in inventory of gasoline and distillate, caused partly by mild weather and inroads by natural gas."

Imperial Oil, Ltd. expects to have a new 100,000-barrel-per-year liquid asphalt plant in operation at its Edmonton, Alta., refinery by June. Costing $210,000, the new system will supplement the 280,000-barrel annual capacity of the solid asphalt plant completed last year. Facilities will include a blender, three tanks, pumps and piping. The new plant will supply several grades of liquid asphalt in time for summer road construction throughout the province. Engineering work is under way, and construction is due to begin very soon.

AviSun Corp. is expanding capacity of its 20-million-pound-per-year polypropylene plant at Port Reading, N. J., to 25 million pounds per year. The company's Port Reading facilities are being leased from Koppers Co., Inc., with an option to purchase. The company reports that, should it purchase the facilities, AviSun polypropylene resin capacity could go to 150 million pounds a year, including the new plant.

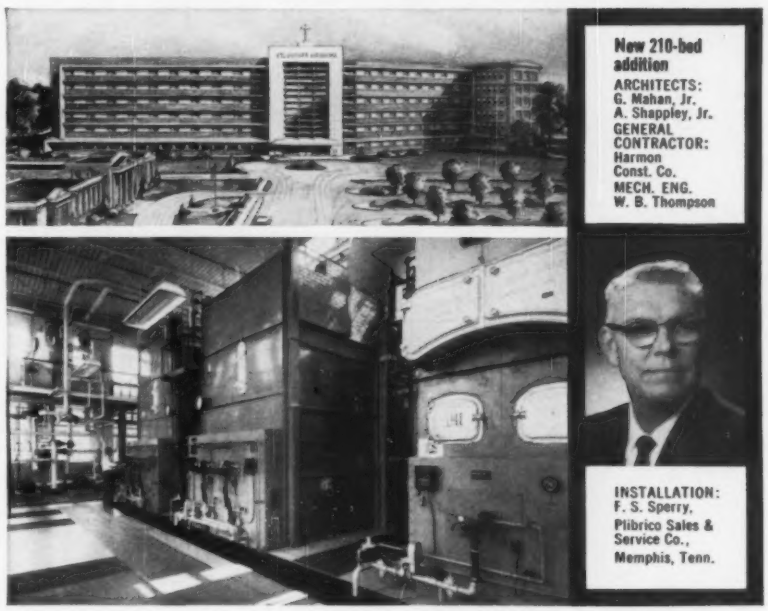
Reichold Chemicals, Inc. has completed construction of $5-million phthalic anhydride plant at Elizabeth, N. J. Built by Badger Manufacturing Co., the new unit has a capacity of 30 million pounds per year.

Petroleo Braziliero is currently building a refinery at Duque de Caxias, Brazil. The plant is being constructed by Foster Wheeler Corp., and supplied by Brefcon, a British consortium formed 18 months ago. The unit will include four reactor vessels (three Houdriformers and a pretreater), accumulators, blow-down drums, kerosine strippers, dissolving tanks and other facilities.

Godfrey L. Cabot, Inc. and United Carbon Co. have completed Australia's first carbon black facilities on a 37-acre site at Altoona, Victoria. The 30-million-pound-per-year plant includes control and technical service labs patterned after parent-company installations in the United States.

Canadian Chieftain Petroleums, Ltd., has completed construction of a new gas processing plant in the Consort area, Alberta. The 10-MMcf-per-day unit has made initial deliveries to Trans-Canada Pipe Lines Co. The plant is owned by Canadian Chieftain (70 percent), Consolidated Mic Mac Oils, Ltd. (15 percent) and Mayfair Oil & Gas Co. (15 percent).

Texas Eastern Transmission Corp. is to start up its new $4-million Rayne, La., gas processing plant this spring. Only pumping equipment for the plant remains to be installed. The 100-150-MMcf-per-day plant will send residue gas through a 30-inch pipe at Opelousas via a 22-mile connecting lateral. When in full operation


New 210-bed addition
ARCHITECTS: G. Mahan, Jr. A. Shappley, Jr.
GENERAL CONTRACTOR: Harmon Const. Co.
MECH. ENG. W. B. Thompson
INSTALLATION: F. S. Sperry, Plibrico Sales & Service Co., Memphis, Tenn.

"Plibrico linings in St. Joseph Hospital boilers . . .

NO REPAIRS AFTER 8 YEARS

. . . these 3 boilers were installed and lined in 1951 with capacity to handle future expansion. Two are 239 hp B and W units, rotated to carry the winter load; the third is a 125 hp Kewanee to handle the summer load. All 3 furnaces are in excellent condition, ready to serve the new 210-bed addition without repairs of any kind " *states Mr. J. Luton, Business Mgr.*

Air-cooled monolithic linings . . . air-cooling lanes in furnace walls reduce heat loss, extend refractory life. Unlike ordinary linings, Plibrico refractory linings are free from joints which so frequently are the cause of early deterioration.

Now is the time to prevent future furnace trouble . . . contact your local Plibrico engineer for a *free inspection.* He is fully qualified to restore your present linings or help you plan a complete installation.

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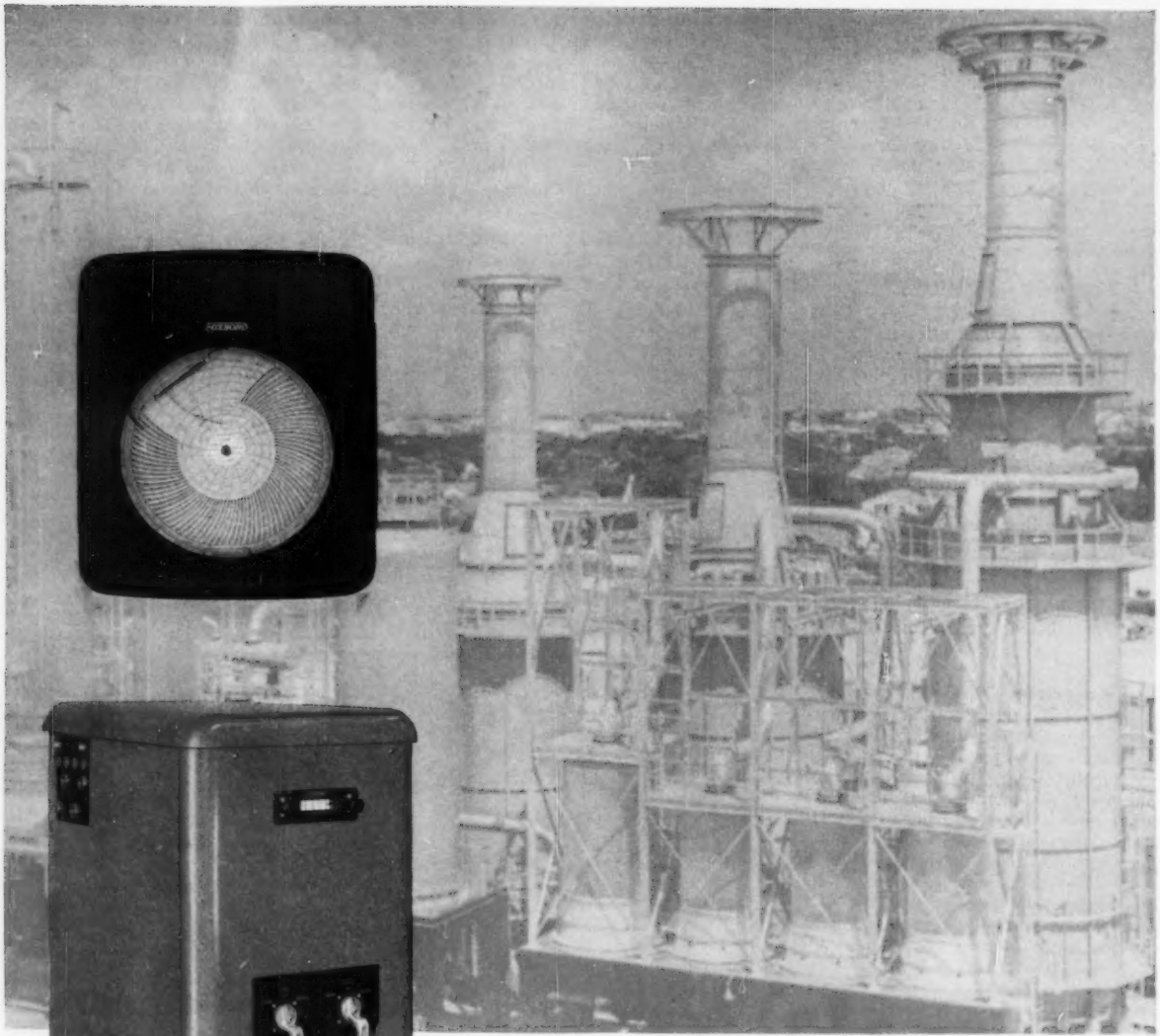

Top: Foxboro Capacitance Dynalog Electronic Recorder

Below: Foxboro Octane Improvement Analyzer

The Foxboro Octane Improvement Analyzer is based on a development of the Humble Oil & Refining Company. The Foxboro Company is licensed to manufacture the analyzer under patent rights held by Esso Research and Engineering Company.

this new Foxboro system lets you measure octane improvement... continuously, automatically

Now you can have a continuous, accurate, automatic reading of octane improvement on any catalytic reformer equipped with the new Foxboro Octane Improvement Analyzer.

Here's how it works. The field-located Analyzer alternately monitors the dielectric constant of the feed stream to — and the product stream from — a catalytic reformer. Both measurements are recorded directly on a Foxboro Capacitance Dynalog* Recorder. And, since a direct correlation exists between dielectric constant difference and octane improvement, the Dynalog chart provides a continuous record of octane improvement.

The Foxboro Octane Improvement Analyzer pays for itself in as little as six months by providing data for faster recovery from reformer upsets. It also substantially reduces the number of knock-engine analyses required. Ask your Foxboro Field Engineer about this unique refining aid. Or write for Technical Information 27-111a. It has all the details. The Foxboro Company, 744 Norfolk St., Foxboro, Massachusetts.

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Building . . .

the plant will recover between 120,000 and 180,000 gallons per day of liquids—primarily propane and butane, with some smaller quantities of hydrocarbons with heavier specific gravity. In addition to the main plant, a low-temperature separation unit will be operated for liquid recovery from the Rayne field gas. This unit has been in operation since last August.

International Petroleum Co., Ltd., has begun engineering on a 300-ton-per-day ammonia plant at Cartagena, Colombia. Also constructed will be a 150-ton-per-day nitric acid plant. Total project is to cost $13 million and be completed in 1961. Engineering is being handled by Esso Research and Engineering Co.

Esso Sirte Libya is planning to construct a 4,000-bpd refinery for Libyan demand, currently about 2,200 bpd. The move was part of an agreement whereby Libya will sell to Esso a 50 percent interest in three tracts of land owned by Libyan American Oil Co. The plant will operate on Libyan crude oil.

J. M. Huber Corp., New York, plans to expand its Baytown, Texas, carbon black plant. The present 60-million-pound-per-year capacity is expected to be doubled. The Baytown plant produces carbon black from heavy residual oil. Construction should begin shortly, with completion slated for late this year.

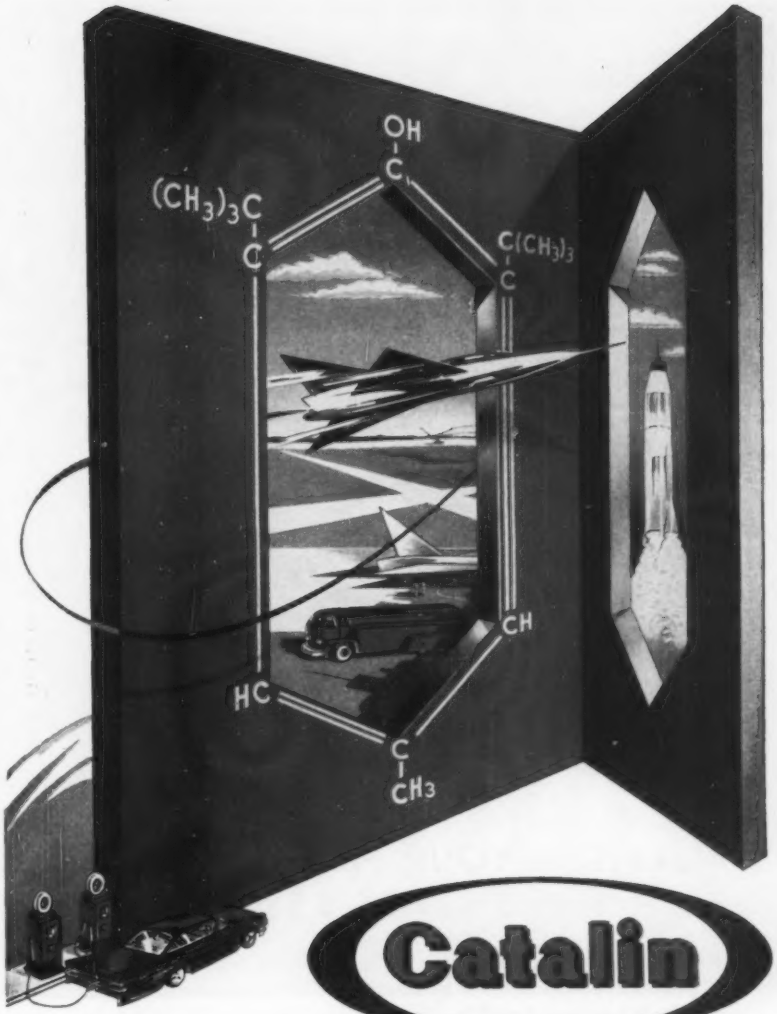
Union Chimique Belge, S.A., Belgium, has awarded a contract for the design, engineering and construction of a 5,000-metric-ton-per-year phthalic anhydride plant to Badger N.V., The Hague. The new phthalic plant will be constructed at Schoonarde at an estimated cost of $2 million.

Krell & Associates, Inc., Houston, plans to build an experimental adsorption plant for petrochemical separations and natural gas processing. The company will also begin a program for designing, fabricating and constructing commercial adsorption units, based on data obtained from the new pilot plant.

U.S.S.R. plans to construct a 230,000-bpd refinery in Russia, in accordance with its current seven-year plan (1959-65). The refinery, reported by Tass, the Russion news agency, will consist of two separate but identical units. It will be completely integrated from crude oil to a comprehensive product line.

Fiber Industries, Inc., a subsidiary of Celanese Corp. of America and Imperial Chemical Industries, Ltd., plans to complete a new polyester fiber plant at Shelby, N. C., this year. The plant will be brought into production in stages, with the first unit, which will produce staple, scheduled to be in operation by mid-year.

Solar Nitrogen Chemicals, Inc., subsidiary of The Standard Oil Co. (Ohio) and Atlas Powder Co., has started



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98.9% PURE* / sets the highest standards for purity and effectiveness

Catalin ANTIOXIDANT CAO-1 . . . the field's finest grade of 2,6-ditertiary-butyl-para-cresol . . . meets U. S. Government military specifications for use in aviation gasolines, turbine and jet fuels. A major advantage achieved with thi heat-resistant, water-insoluble antioxidant is that high-octane fuels are effectively protected, with no loss of octane rating. Gum and peroxide formations are inhibited, and deposits in the aircraft intake manifold and engine are markedly reduced.

Catalin ANTIOXIDANT CAO-1 stabilizes high-octane automotive gasolines, as well as turbine, insulating, hydraulic and transformer oils . . . in fact, nearly any petroleum hydrocarbon exposed to oxidizing conditions.

Samples, literature and technical assistance wait upon your request. Inquiries invited.

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chemicals plastics resins

* *Typical Analysis*

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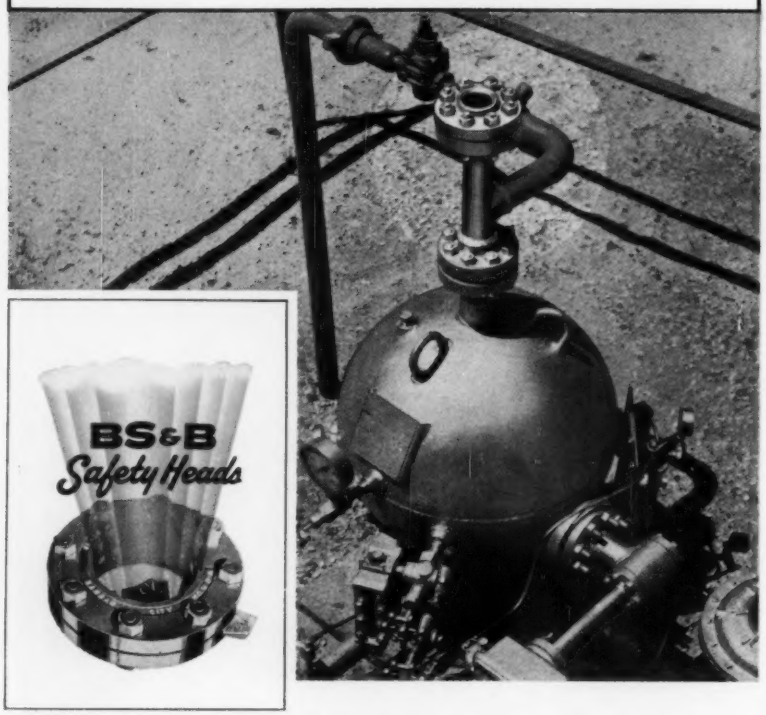
Why Gamble With Overpressure?



Make Sure YOUR Pressure Systems are Protected with BS&B Safety Heads

Pressure relief is an important consideration in the operation of pressure equipment. A sudden surge of overpressure could result in serious trouble . . . extensive damage to valuable equipment . . . serious injury to personnel or even loss of life.

Pressure systems may be protected with relief valves—being sized for normal overpressure conditions. However, there are times when relief valve capacity cannot handle overpressure buildups fast enough. Or valves may not function properly because of corrosion or "freeze-ups."

For standby relief, BS&B Safety Heads are the answer.

The BS&B Safety Head relieves undesirable pressure build-ups instantly, rapidly reducing pressure within a system to a safe zone of operation.

BS&B sales engineers will be glad to inspect your pressure systems with you and help recommend proper pressure protection of your equipment. Call your local BS&B office. Or write to Central Sales Engineering in Kansas City.

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Safety Head Division, Dept. 2-F4
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Building . . .

a $2-million expansion of its ammonia, urea, nitric acid and nitrate facilities at Lima, Ohio. The project, to be completed by the end of this year, will increase the company's ammonia production by 25,000 tons a year.

Carbosuf Chemische Werke G.m.b.H. has been formed by Glanzstoff Courtaulds G.m.b.H. of Cologne, Germany, and Chemische Fabrik G.m.b.H. of Bad Kreuznach. The new company will build a 52,000-ton-per-year carbon disulphide plant in Cologne, Germany. To be completed in two years, it will get raw materials from petrochemical plants in the Cologne area.

Ente Nazionale Idrocarburi has started construction of a joint Italian-Moroccan refinery at Mohammedia, about 20 miles from Casablanca. The 20,000-bpd, $14-million plant, to be on stream in 1962, will be operated by Samir, and financed by ENI and Morocco on a 50-50 basis. The port of Mohammedia can dock 12,000-ton tankers, and handle 40,000-ton vessels offshore.

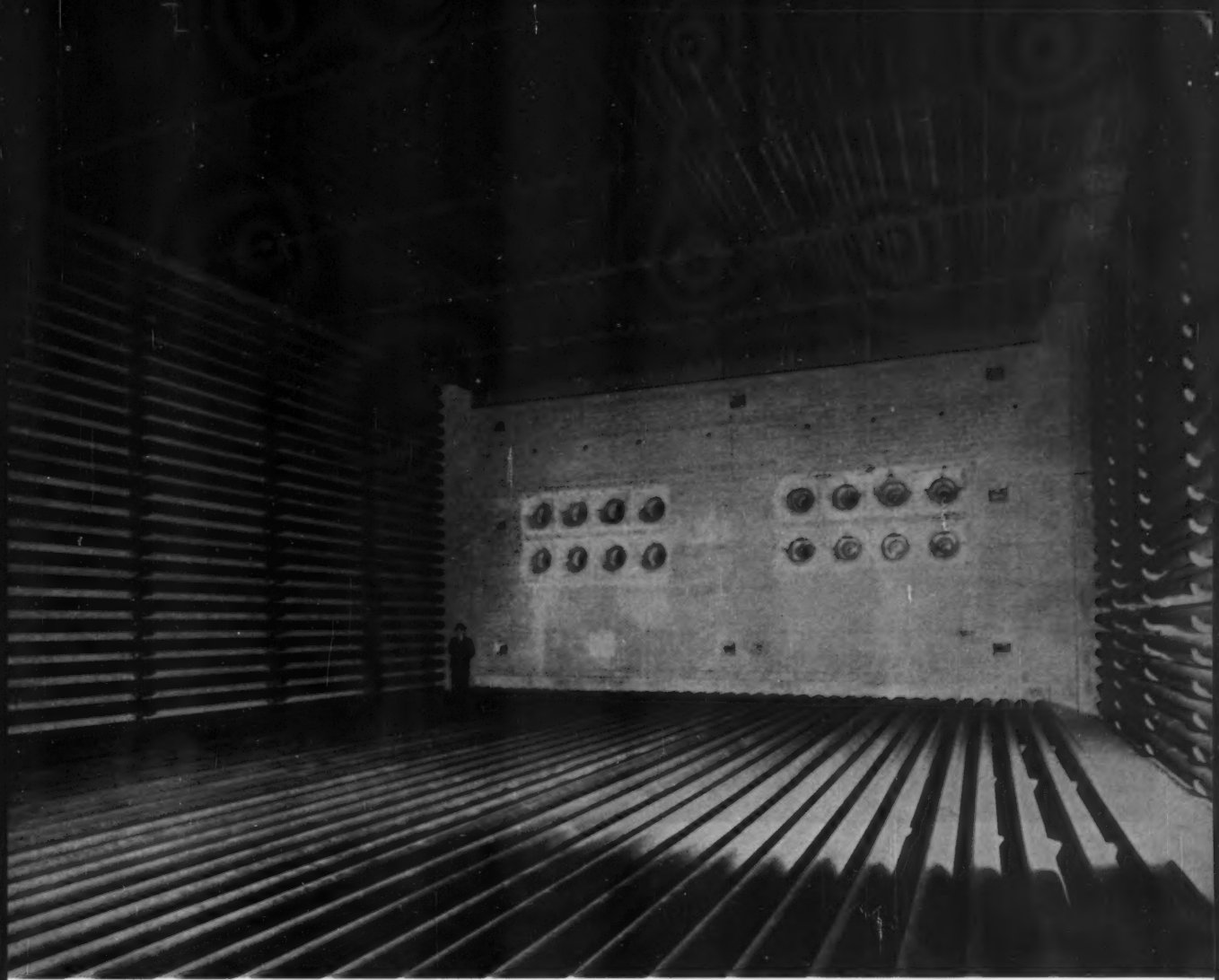
Oelwerke Julius Schindler G.m.b.H., an associate firm of British Petroleum Co., is constructing a new dewaxing unit at the Neuhof refinery, near Hamburg, Germany. It will have a capacity of 350 metric tons and will produce high-viscosity lubricating oils. The new dewaxer, with its ancillary equipment, will cost $4.76 million and will be in operation in 1961.

Goliad Corp. and Union Oil Co. of Calif. are currently building two new natural gasoline plants in Louisiana at a cost of about $12 million. The two firms are building a new 450-MMcf-per-day refrigerated oil adsorption plant at Kaplan (see December 1959 issue, page 164). An 85-mile pipe line will connect this plant with Wyandotte Chemical Co.'s Geismer plant.

Imperial Chemical Industries, Inc. is expanding its solvents plant at Castner-Kellner works, Runcorn, England. The company anticipates that the expansion will lower production costs and increase the firm's total capacity of perchlorethylene and trichlorethylene by 25 percent. The $2.8-million expansion is to be completed in 1961.

W. R. Grace & Co. has started a major expansion at Grace Chemical Division's Memphis, Tenn., nitrogen plant. Capacity of the 100,000-ton-per-year plant will go to 160,000 tons of ammonia. This expansion follows an earlier one for the urea section, which was doubled in 1959. Added urea facilities bring capacity to 100,000 tons per year.

Dow Badische Chemical Co.'s caprolactam plant, currently under construction at Freeport, Texas, is slated to come on stream in January 1962. The 40-million-pound-per-year unit will supply



Why so big?

This direct-fired Foster Wheeler heater is one of the world's largest for sound economic reasons. It serves a 125,000 bbl/day crude distillation unit at Gulf Oil Corporation's Girard Point refinery.

Although Foster Wheeler engineers put this heater into service several years ago, very few direct-fired heaters built since can match either its size... 284,075,000 Btu/hr absorbed—or performance . . . six full years of reliable, trouble-free operation.

Remember this example of FW heater know-how the next time you are faced with the problem of specifying a process heater.

Consider the assistance FW engineers can offer. You will find them both ingenious and practical in providing a heater tailored to your process *and to your budget.* Backed by 40 successful years of direct-fired heater design and construction, FW engineers give you the best in equipment performance and reliability.

FW can furnish you with a full line of both vertical and horizontal heaters to meet the widest possible range of process requirements. Contact Foster Wheeler Corporation, Department B, 666 Fifth Avenue, New York 19, N. Y.

Heat Engineered products, plants and processes . . . for the world's industrial progress.

FOSTER WHEELER

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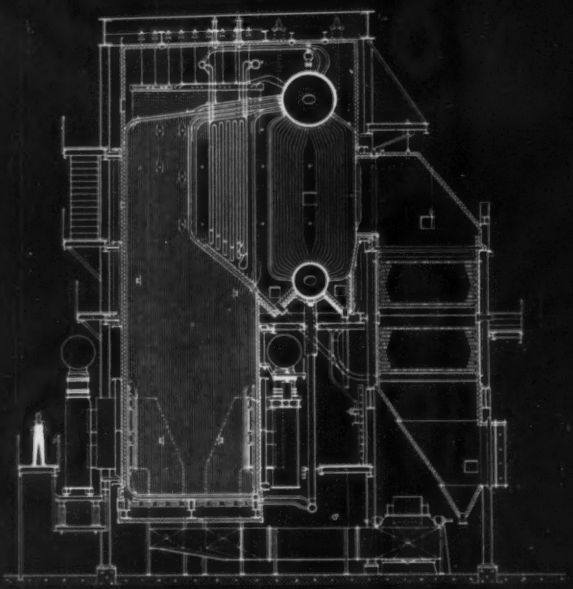
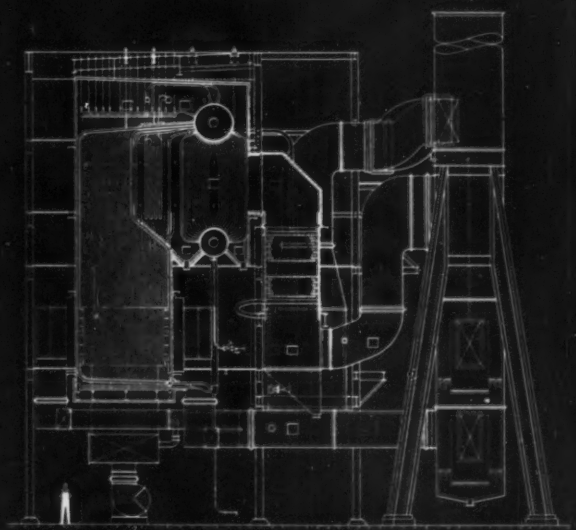
This unit delivers 175,000 lb of 750F steam per hour at 650 psig. In addition to CO gas, it burns pitch, refinery gas and Bunker C oil.



One of two CO boilers for a Texas refinery. Oxygen for combustion is supplied by the exhaust from the gas turbines which drive the regenerator compressors. Steam conditions are 177,000 lb per hr, 625 psig and 700F.



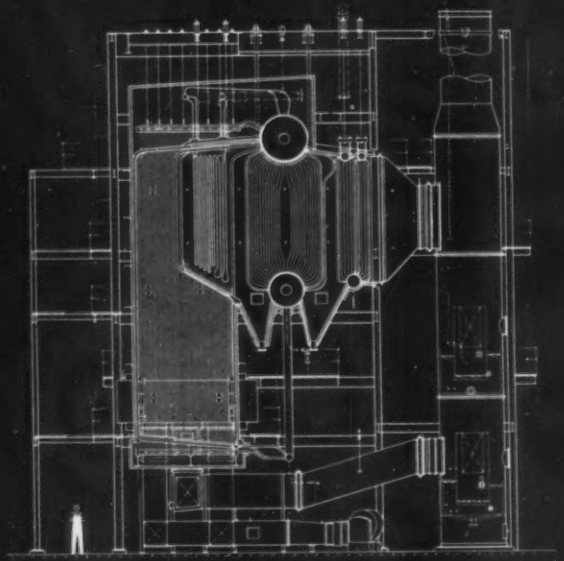
If you're looking for the best catalyst regenerator gas

Here are 8 reasons why

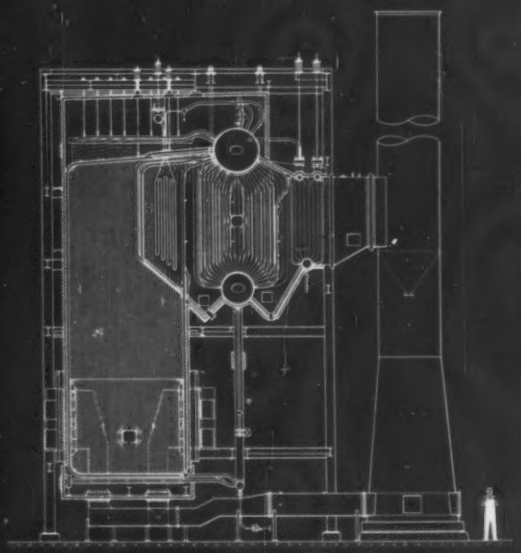
1. **YOU'LL WANT HIGH AVAILABILITY**
   And the records show that the first CO Boiler placed in service by C-E has been on the line for more than two years without a single unscheduled boiler outage.
2. **YOU'LL WANT OPTIMUM RETURN**
   And CO Boilers by C-E burn regenerator gas efficiently *from minimum to maximum loads.*
3. **YOU'LL WANT LOW POWER CONSUMPTION**
   And CO Boilers by C-E provide minimum air pressure loss and minimum fan horsepower requirements.
4. **YOU'LL WANT LOW MAINTENANCE**
   And double steel, skin cased CO Boilers by C-E contain a minimum of exposed refractory.
5. **YOU'LL WANT THE MOST EFFECTIVE USE OF MATERIALS**
   And C-E makes optimum use of boiler and superheater – gas passage areas and heating surfaces are uniformly distributed across the width of the unit.
6. **YOU'LL WANT ADVANCED DESIGN**
   And C-E Tangential Burners provide complete and positive mixing of air, auxiliary fuel and CO gas, preparing the combination for instantaneous ignition on injection in the furnace.
7. **YOU'LL WANT MAXIMUM CONTROL OF THE COMBUSTION PROCESS**
   And CO Boilers by C-E offer individual, shielded cut-off dampers for each CO gas burner and individual air control for every burner.
8. **YOU'LL WANT A PRODUCT THAT HAS PROVEN ITSELF**
   In terms of general experience, a total of more than 675 tangentially fired C-E boilers have been purchased to date for use with various fuels. As to specific experience with lean fuels, C-E – in addition to its CO Boiler installations in refineries – has installed more than 150 boilers burning blast furnace gas . . . a fuel similar to CO gas with a heating value of about 80 Btu per cubic foot.

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS;

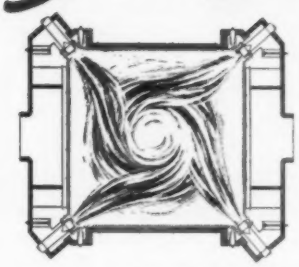
This unit is designed to produce 85,000 lb of 750F steam per hour at 625 psig. Note the C-E seal tank arrangement in the bottom-supported stack.



In its third year of service, this unit provides 100,000 lb of 550F steam per hour at a pressure of 250 psig. It has been off the line only when the cat cracker was removed from service for scheduled maintenance.

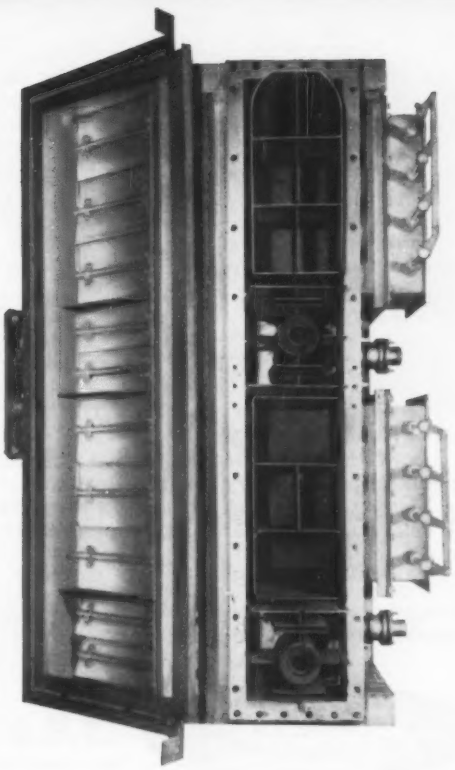


boiler to burn See C-E



Plan view diagram showing principle of tangential firing in a completely water-cooled furnace.

The C-E Tangential Burner for CO gas. Zone controlled, dampered air inlets are shown at left, dampered CO gas inlets at right. The center panel is a furnace view of the burner The oil burners in the cen ter and bottom compartments are flanked by flat head burners for natural or refinery gas firing. CO gas is admitted through the other ports.



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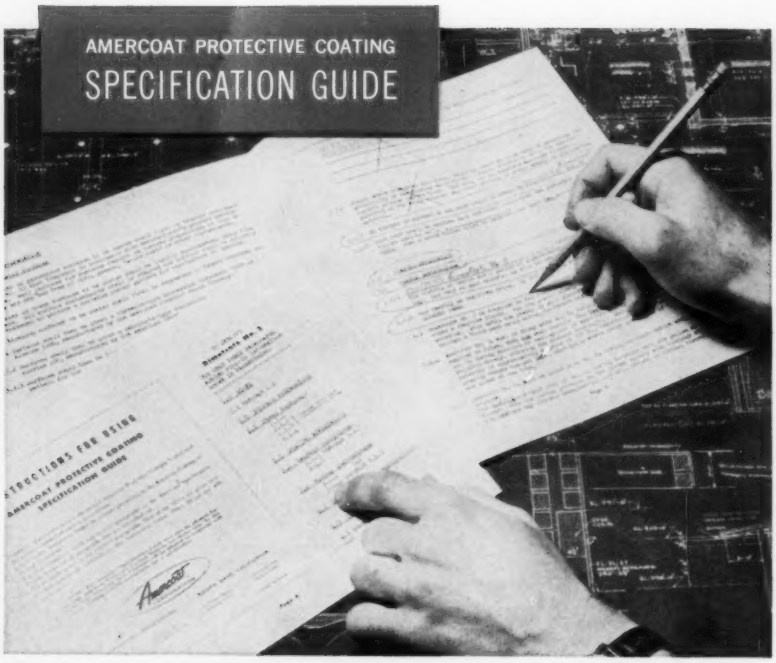

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Tight, comprehensive specifications are the beginning of a successful protective coating application. Unless specifications are complete and detailed, costly failures or confused, inaccurate bidding can result.

Now, engineers who write specifications for protective coating applications can insure complete, accurate specifications through use of the new Amercoat Protective Coating Specification Guide.

The Guide is based on recognized best practices in the industry, such as Steel Structures Painting Council Specifications, and contains paragraphs covering all phases of coating application from surface preparation to inspection.

In use, appropriate paragraphs in the Guide are selected according to the coating to be used and the condition involved. At this step, your Amercoat Sales Engineer will be pleased to cooperate with you in deciding upon the most effective coating or coating system for the job requirements. The finished specifications can then be copied by a typist.

Use of the Amercoat Specification Guide assures tight specifications that spell out every step necessary to eliminate confusion when the contractor bids and to insure a satisfactory application later. Job delays and extras are reduced or eliminated and a well applied coating job is assured.

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Building . . .

Dow's nylon plant at Williamsburg, Pa., to be completed late in 1961. Dow Chemical will use about 12 million pounds of the material, and the remainder will be sold.

Pakistan Petroleum, Ltd. is having a 3,000-ton gas processing plant shipped to it from the Port of Houston. The $3-million plant was sold to the company by Hudson Enginering Co., Houston, designers. The 75-MMcf-per-day unit is to be installed and in operation by October. Purchase is being financed by the Development Loan Fund, International Cooperation Administration.

Monsanto Andes, S.A.I.C. has completed its Mendoza, Argentina, plant for the production of polyvinyl chloride resins and vinyl chloride monomer. Monsanto Argentina, S.A.I.C., Monsanto Chemical Co.'s other subsidiary in Argentina and that nation's first polystyrene producer, will compound resins at Zarate.

California Texas Oil Co. is establishing a new company to own and operate a 21,000-bpd refinery at Izmit, Turkey. The new firm will be known as Istanbul Petrol Rafinerisi (IRPAS). Caltex is an affiliate of Standard Oil Co. of Calif. and Texaco, Inc.

Suntide Refining Co.'s new Corpus Christi, Texas, delayed coking unit (see February 1960 issue, page 182) is currently producing 7,000 bpd of petroleum coke, propane, propylene, butane-butylene, gasoline and gas oil. The unit cost about $3 million.

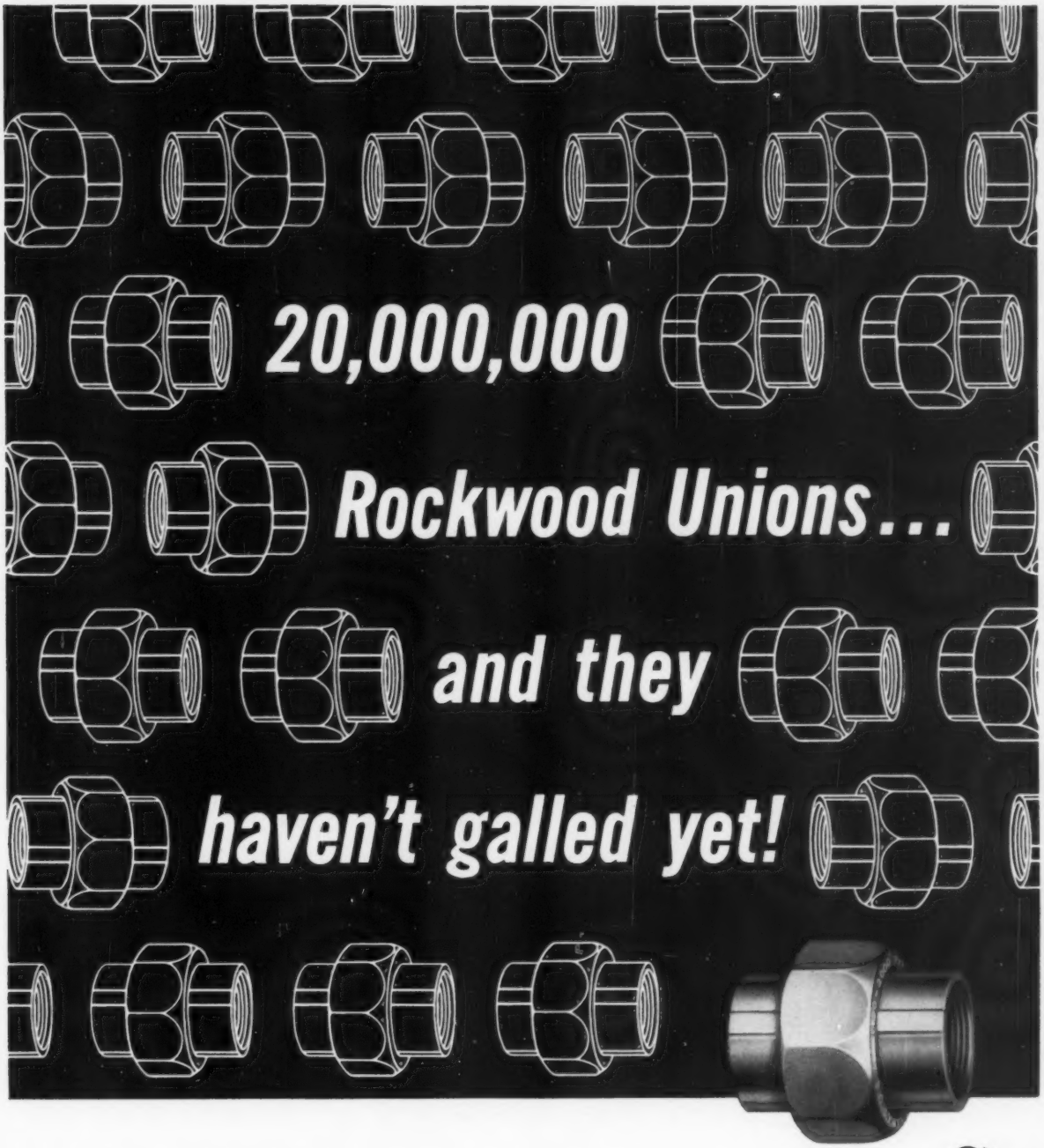
Barbados Union Oil Co. will expand its Barbados refinery to 1,000 bpd. Mobil International Oil Co. has acquired a minority interest in the firm, and will help with construction. Barbados Union will supply Mobil with industrial and automotive fuels.

Hungary is reportedly planning to build a 60,000-bpd refinery next year outside Budapest on the Danube River. The plant, which would be highly automated, would receive crude oil through the planned USSR-East European pipe line.

Spain's Ministry of Industry is expected to grant approval for a new 30,000-bpd refinery at the Port of Vigo. The $15-million plant is being considered by a group of Spanish industrialists living in the United States.

Amoco Chemical Corp. has placed its Joliet, Ill., phthalic anhydride plant into operation on a limited basis, after a year's delay caused by mechanical trouble. Full-scale production is reportedly still well into the future.

The Dow Chemical Co. plans to construct a nylon plant at its James River Division, Williamsburg, Va. The multimillion-dollar plant will have an initial capacity of 12 million pounds per year of filament yarn, primarily for use in



Only ROCKWOOD Cold Forged Steel Unions have the hardness differential which *assures* fast, easy make-up, a tight seal, and free from galling. Male seat is heat-treated to a hardness substantially higher than that of the female seat. Then both seats are forged in place and double-locked under 100,000 and 400,000-pound pressures. Other outstanding features include: special color-coding for immediate identification. Rockwoodizing which gives all surfaces *positive* protection against corrosion, interchangeable parts. Get complete information now. Write for facts.

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For more data on advertised products, use Readers' Service Cards, last page

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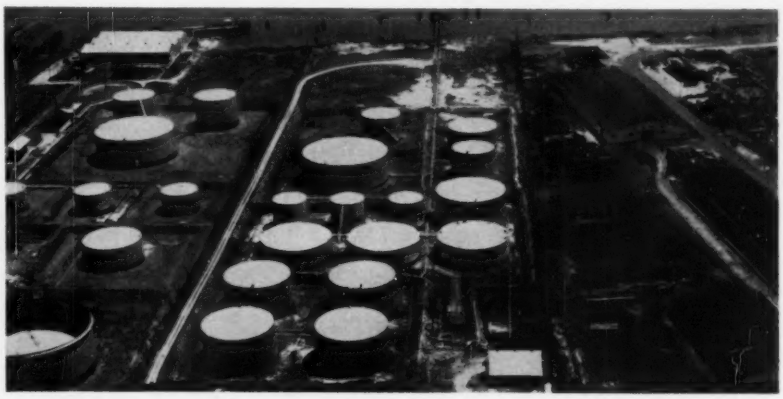
tire manufacture. Construction will start this month and completion is scheduled for late 1961. The new plant will in no way affect operations at the Zefran plant, which is producing staple fiber for apparel and other uses. Caprolactam, the principal raw material used in nylon production, will be obtained from Dow Badische Chemical Co., Freeport, Texas.



Delhi-Taylor Completes Big Tank Farm

Delhi-Taylor Oil Corp. has completed a 2-million-gallon petrochemicals marketing terminal at North Charleston, S.C. The terminal will be the distribution center for toluene, xylene, mineral spirits and high-grade solvents to the textile, paint and chemical industries of the Southeast. Petrochemicals will be shipped by tanker from the company's plant at Corpus Christi, Texas, to the Charleston terminal and distributed to customers by tank car, barge and tank truck.

Home Oil Co., Ltd. is considering a 100 percent increase in capacity of its Carstairs, Alb., gas processing plant, still under construction. The $3.7-million plant, to be completed this month, was to have a capacity of 75 MMcf per day, but this will be increased because of unexpected field reserves, and a seventh gas well recently completed.

Chemoil Corp. is planning to build a 40,000-bpd refinery somewhere in Louisiana. The $40-million unit will be constructed by The Lummus Co.

Texaco, Inc. has completed construction of a 1,600-bpd sulfuric acid alkylation unit at its El Paso, Texas, works. The alkylate will be used to upgrade gasoline quality.

E. I. duPont de Nemours & Co. has started construction of its new sulfuric acid alkylation plant at La Porte, Texas. The multimillion-dollar unit is slated to come on stream in about one year.

Pittsburgh Coke & Chemical Co. has begun expansion work on a sulfuric acid alkylation unit at Neville Island, Pa. The plant will increase its capacity by about 70 percent.

Showa Denko, K.K., Japan, will build a new carbon black plant in Japan. The unit will utilize the Phillips Petroleum Co. oil-furnace-black process. Slated to be completed in about three years, the plant is being designed by Phillips.

Texas Butadiene & Chemical Corp. is planning to build a petrochemical complex including a synthetic rubber plant and an adjacent butadiene plant in the vicinity of Puerto Deseado, Argentina. The Argentine Government has issued a decree sanctioning the project, and ground-breaking is expected to take place in the near future.

Australian Petrochemicals, Ltd., has been formed by Monsanto Chemical Co. and Petroleum and Chemicals Corp., Ltd., Sydney, to build a styrene plant at Sydney. The plant is slated for completion in 1961.

Bolivian Oil Co. plans to build an 8,000-ton-per-year carbon black plant in Bolivia, using locally produced gas. The proposed $3-million project awaits approval of the Bolivian Petroleum Agency.

Allied Chemical Corp.'s Semet-Solvay Division plans to expand its Tonawanda, N.Y., polyethylene plant capacity 10-20 percent this year. Total capacity at the end of 1959 was about 30 million pounds.

Benzin und Petroleum A.G. plans to begin construction of the second phase of its Wesel, Germany, refinery this summer. The project will bring the refinery's capacity to 88,000 bpd.

Cia. Espanola de Petroleos is planning to up the capacity of its Las Palmas, Canary Islands, refinery from 60,000 bpd to 72,000 bpd. Cost of the project has been estimated at about $11 million.

For more data on advertised products, use Readers' Service Cards, last page.

Allied Chemical Announces 50% Boost in HF Capacity at Nitro, W. Va. Plant
New York, N. Y. (Special)—Allied Chemical's General Chemical Division announced today that it is expanding by 50% the productive capacity of its anhydrous hydrofluoric acid plant at Nitro, W. Va. This is one of several developments which strengthen Allied Chemical's position in fluorine chemicals
OVER 1,000,000 TONS OF ADDED FLUORSPAR RESERVES ACQUIRED BY ALLIED CHEMICAL
New York, N. Y. (Special)—Acquisition of major new reserves of fluorspar, totalling more than a million tons, has been announced by Allied Chemical Corporation. These buttress the Corporation's position in fluorine chemistry and provide additional raw material resources for long range future hydrofluoric acid production

2 More Big Reasons for Making General Chemical *Your HQ for HF*

General Chemical recently announced two developments of interest to every consumer of hydrofluoric acid—a 50% increase in anhydrous HF capacity at Nitro, W. Va., and the acquisition of more than 1,000,000 tons of additional fluorspar reserves. Both announcements underscore General's position as the nation's leading supplier of aqueous and anhydrous hydrofluoric acid.

Here are more good reasons why it pays to make General *your HQ for HF:*

Eight HF supply locations, three producing plants! General Chemical maintains eight HF supply points. Of these, three plants located in North Claymont, Delaware; Baton Rouge, Louisiana; and Nitro, West Virginia, make General Chemical the *only* supplier offering shipment of anhydrous as well as aqueous from more than one producing location.

In addition, General Chemical maintains five aqueous HF bulk storage and packaging stations at Buffalo, N. Y.; Chicago, Ill.; Cleveland, Ohio; El Segundo (Los Angeles), Calif.; and Pittsburgh, Pa. These five points back each other up and further assure service and availability of HF at all times, under all conditions.

Basic position! General Chemical owns and operates its own fluorspar mines and mills . . . and is the country's leading producer of sulfuric acid. This basic position in the essential raw materials for hydrofluoric acid production is your best assurance of dependable supply.

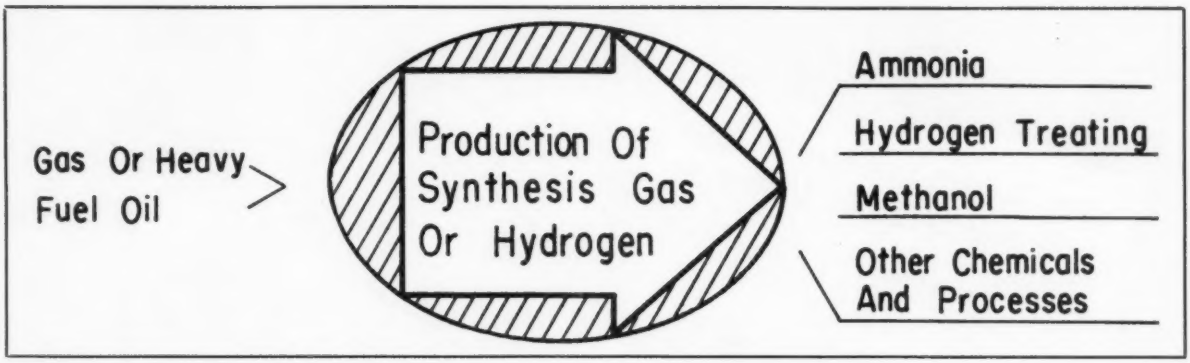
If you'd like more information as to how we can serve you, just drop us a line. Why not do it now?

Basic to America's Progress

Allied Chemical

GENERAL CHEMICAL DIVISION

40 Rector Street, New York 6, N. Y.



Big Future for Hydrogen Processing

Over-all consumption of synthesis gas and hydrogen should hit about 1,250 billion cubic feet per year by 1965

HYDROGEN, though a lightweight, will give the appearance of a heavyweight champion for growth in the immediate future. The chemical and process industries have recognized the need for a substantial increase in hydrogen and synthesis gas production capacity.

What's Ahead. The projected increase in capacity of presently large uses, in conjunction with tremendous potential growth of presently small uses, make it very likely that overall consumption of synthesis gas and hydrogen will increase rapidly. It is estimated the total U.S. consumption in 1965 will be in the range of 1,000 to 1,250 billion cubic feet per year. This is about twice present capacity. Based on a heavy fuel oil feed, this would require, for example, the gasification of as much as 77 million barrels per year of heavy fuel oil, with an additional 6 million barrels of fuel required for preheating.

Because a large percentage of synthesis gas (essentially hydrogen and carbon monoxide) is converted to hydrogen through shift conversion and purification, it appears both proper and convenient to express commercial applications of synthesis gas in terms of both synthesis gas and hydrogen. Some of the more important applications of these products are as follows:

Ammonia Production. The largest single use for hydrogen today is in the production of synthetic ammonia. Plants in the United States alone produce about 5 million tons of ammonia per year. It is predicted this production will be increased about 40 percent by 1965. Since each ton of ammonia requires about 70,000 SCF of hydrogen, the additional hydrogen producing capacity needed would amount to about 140 billion cubic feet per year.

Methanol Production. The methanol market has enjoyed a tremendous growth rate over the past 12 years, one of the recent commercial applications being as a takeoff assist fuel for both jet-powered and piston-powered aircraft. Current methanol production in the United States is about 300 million gallons per year, requiring about 100 billion cubic feet per year of synthesis gas. It is estimated the growth of methanol production will require an additional 80 billion cubic feet of synthesis gas per year by 1965.

Petroleum Refining. Hydrogen is presently used in petroleum refining in a considerable number of hydrogenation processes. Among the outstanding benefits achieved by its use are improvement in product quality, preparation of unsuitable feed stocks for catalytic processing, reduction in corrosion, increase in yield of lighter and more valuable products, and improvement of catalyst life.

The present major uses of hydrogen in refining are in the pretreatment of catalytic reformer feed stocks, the hydrogenation of catalytic cycle oils, and the hydrogen treatment of gasolines, kerosines, distillates, and lube stocks. These requirements for hydrogen have, for the most part, been served by hydrogen produced from catalytic reforming processes. However, it will be necessary to provide auxiliary hydrogen production facilities to meet these needs.

While present major uses of hydrogen by refiners will undoubtedly increase, it is expected that a major portion of increased consumption may come from other processes either relatively new, or which have so far had limited commercial application. Some of the processes that show potential for large scale hydrogen consumption are as follows:

- New hydrocracking processes which convert such stocks as heavy cracked naphthas and cycle oils to catalytic reformer feeds and gasoline blending stocks.
- Hydrogenation of aromatics to bi-cyclic alkyl naphthenes, which appear to have the qualities required of

high performance turbojet fuels.

- Hydrogenation of products from the refining of shale oil and solid hydrocarbons such as gilsonite ore.
- Hydrogenation of low-gravity and high-sulfur crudes and residua for removal of sulfur and increased production of gasoline and distillates.
- The purity requirements for refinery hydrogenation processes are low. Typical purities used are 95 percent hydrogen.

The use of hydrogen in petroleum refining is expected to increase to about 350 billion cubic feet in 1965. Although part of this increase will be supplied as by-product from reforming processes, it is estimated an added hydrogen production capacity of about 100 to 150 billion cubic feet per year will be required.

Other Uses. Some other uses of hydrogen and synthesis gas with excellent growth potential are as follows:

- Hydrogenation of vegetable and animal fats and oils.
- Liquid hydrogen as a high-energy fuel for rockets and missiles. Hydrogen has the highest heat of combustion per pound of any material known.
- Hydrogen in manufacture of high energy fuel components, such as hydrogen peroxide and boron hydrides.
- Synthesis gas in reduction of metallic ores. This has a large potential since each percent of conversion to this method of reduction in iron ore alone would increase required capacity by about 30 billion cubic feet per year.
- Hydrogenation of organic intermediates.
- Synthetic fuel production from synthesis gas.
- Aldehydes and alcohols from synthesis gas.

How Hydrogen is Made. A method widely used for preparation of synthesis gas, particularly where low cost natural gas is available, is steam-methane reforming. This reaction is also highly endothermic, but is carried out as a continuous process utilizing a catalyst packed in externally heated alloy tubes. The equilibrium of the stream-methane reaction requires relatively high temperatures, which imposes a limitation on the pressures that can be used even with the best available alloys. Furthermore, steam reforming is limited to such charge stocks as natural gas and low boiling liquid hydrocarbons.

In another method, synthesis gas is produced by means of a non-catalytic flame reaction between a liquid or gaseous hydrocarbon feed stock and oxygen. Units can be designed to accept a very wide range of hydrocarbon feeds, including natural gas, butanes, distillates, crudes, and heavy residuums. In the case of heavy oils, that is those with a high weight percentage of carbon, steam also is fed to the generation system. The reaction pressures normally used are relatively high, typically in the range of 400 to 500 psig. Since the production of synthesis gas proceeds with a large increase in volume, this can substantially reduce over-all compression costs as well as reduce equipment sizes.

Synthesis gas can also be made from coal, as it was for many years. However, the process was generally limited to areas where coking coal was readily available.

Condensed from a presentation by H. N. Olson and P. E. Schueider, Southwestern Engineering Co., Los Angeles. The presentation was made before the Western Petroleum Refiners Association, Corpus Christi, Texas, January 1960.

You can review the construction of plants for making synthesis gas and hydrogen, as well as other important construction projects, in PETROLEUM REFINER'S Construction Boxscore which follows:

Construction Boxscore

Oil, Gas and Petrochemical Processing Plants

East

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Allied Chemical	Moundsville, W. Va.	Fumaric Acid	.....	.....	Under Constr	Mid 1960	.....	.....	.....
American Cyanamid	Bridgeville, Pa.	Maleic Anhydride	20,000,000 lbs/yr	.....	Under Constr	Mid 1960	S D	S D	S D
	Bound Brook, N.J.	Phthalic Anhydride	7,000,000 lbs/yr	.....	Under Constr	Spring 1960	.....	.....	Foster Wheeler
Ashland O&R	Buffalo, N.Y.	Naphthalene	50,000,000 gal/yr	.....	Under Constr	.....	UOP	.....	.....
		Benzene	12,000,000 gal/yr	.....	Under Constr	.....	UOP	.....	.....
Atlantic Refining	Philadelphia	Crude Revamp	20,000 bbls	$2,000,000	Complete	.....	.....	Staff	.....
AviSun	Eastern U.S.	*Polypropylene Resin	100,000,000 lbs/yr	$30,000,000	Engineering	May 1961	Staff	Bechtel	Bechtel
Borden Chemical	Leominster, Mass.	*Pilot Plant for Polyvinyl Alcohol & Acetate, Acrylics, and Butadiene-Styrene	1,000 lbs	$2,000,000	Complete	.....	.....	.....	.....
Cary Chemicals	Flemington, N.J.	Polyvinyl Chloride, Polymers	.....	.....	Under Constr	1960	SD	SD	SD
Dow Chemical	Allyn's Point, Conn.	Styrene-Butadiene Latexes	.....	.....	Engineering	Early 1961	.....	.....	.....
Du Pont	Belle, W. Va.	Urea, Ammonia, Methyl Methacrylate, Nylon Intermediates	.....	.....	Planning	1961	Texaco	.....	.....
	Florence, S.C.	Polyester	.....	$20,000,000	Under Constr	1961	.....	.....	.....
	Memphis, Tenn.	Acrylonitrile	.....	.....	Under Constr	.....	.....	.....	.....
	New Jersey	Hydrogen	.....	.....	Engineering	.....	.....	Chemico	Chemico
Esso Standard	Bayway, N.J.	Exp. Cat Cracker Light Ends	.....	.....	Under Constr	Early 1960	.....	.....	.....
	Bayonne, N.J.	Asphalt	.....	.....	Under Constr	Spring 1960	.....	.....	.....
Ethyl	Orangeburg, S.C.	*Aluminum Alkyls, Alkyl Aluminum Halides	.....	.....	.....	Complete	.....	.....	.....
Foster Grant	Leominster, Mass.	Plastic Polymers, Copolymers, Styrene Monomer, Molded Plastics	.....	$4,000,000	Planning	.....	.....	.....	.....
Frontier Refining	Jacksonville, Fla.	Refinery	10,000 bbls	.....	Planning	.....	.....	.....	.....
Grace Chemical Div., W.R. Grace	Memphis	Exp. Ammonia	450 tons	.....	Under Constr	Mid 1961	.....	.....	.....
Gulf Oil	Philadelphia	Oxo Alcohols	35,000,000 lbs/yr	.....	Under Constr	Dec 1960	Gulf Oil	BadgerMfg/Gulf	BadgerMfg/Gulf
	Charleston, S.C.	*Exp. Ethylene	.....	.....	Planning	Summer 1960	.....	.....	.....

*First appearance in tabulation.

Construction BOXSCORE continued on Page 258

CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Hercules Powder	Burlington, N.J.	Dimethyl Terphthalate	36,000,000 lbs/yr	.....	Under Constr	Oct 1960	.....	.....	.....
Hess Trading & Transport	Sewaren, N.J.	*Exp. Refinery	35,000 bbls	.....	Planning	.....	.....	.....	.....
		*Udex	.....	.....	Planning	.....	.....	.....	.....
		*Catalytic Cracking	.....	.....	Planning	.....	.....	.....	.....
Heyden Newport Chemical	Fords, N.J.	*Maleic Anhydride	24,000,000 lbs/yr	.....	Under Constr	Late 1960	.....	S D	S D
Kendall Refining	Bradford, Pa.	*Crude Revamp	5,000 bbls	$160,000	Engineering	Summer 1960	.....	Letwin	Staff
Koppers	Follansbee, W. Va.	*Desulfurization	60,000,000 lbs/yr	.....	Under Constr	Late 1960	.....	Staff	Staff
Mobay Chemical	New Martinsville, W. Va.	*Exp. Toluene Diisocyanate	13,000,000 lbs/yr	.....	Under Constr	July 1960	.....	.....	.....
Novamont	Neal, W. Va.	Isotactic Polypropylene, Other Petrochemicals	22,000,000 lbs/yr	.....	Under Constr	Early 1961	Montecotini	Staff	Staff
Olin Mathieson	Brandenburg, Ky.	*Ethylene Oxide	.....	.....	Under Constr	Late 1960	Shell Devel	Lummus	Lummus
Pantasote	Passaic, N.J.	Polyvinyl Chloride	.....	.....	Under Constr	1960	SD	SD	SD
Pittsburgh Coke & Chemical	Neville Island, Pa.	Maleic Anhydride	20,000,000 lbs/yr	.....	Planning	Early 1961	.....	SD	SD
Quaker State Oil Refining	Farmers Valley, Pa.	Exp. Refinery	.....	$400,000	.....	.....	.....	.....	.....
Reichhold Chemicals	Elizabeth, N.J.	Maleic Anhydride	20,000,000 lbs/yr	$4,000,000	Engineering	June 1960	Badger Mfg.	Badger Mfg.	Badger Mfg.
	Hampton, S.C.	Formaldehyde	30,000,000 lbs/yr	.....	Engineering	.....	.....	.....	.....
	Tuscaloosa, Ala.	Formaldehyde	35,000,000 lbs/yr	.....	Planning	.....	Staff	Staff	Staff
		*Phenol	.....	$2,500,000	Under Constr	.....	.....	.....	.....
Shell Oil	Little Creek, Miss.	Natural Gas Liquids	5MMcf	.....	Planning	.....	.....	.....	.....
Stauffer Chemical	Le Moyne, Ala.	Methane Purification	.....	.....	Engineering	Spring 1960	.....	Treco	Treco
	Delaware City, Del.	Carbon Bisulfide	.....	.....	Planning	Nov 1960	.....	Staff	
Sun Oil	Marcus Hook	Propylene Fractionating	60,000,000 lbs/yr	$1,965,000	Complete	.....	.....	Staff	Staff, others
		Exp & Modernize Grease Plant	.....	$450,000	Under Constr	1960	.....	Staff	Staff
		Exp. Wax Moulding and Packaging	.....	$637,000	Under Constr	1960	.....	Staff	Staff
		Automatic Tank Gauging	.....	$423,000	Under Constr	Spring 1960	.....	Staff	Staff
		Chassis Dynamometer Addition	.....	$352,000	Under Constr	1960	.....	Staff	Staff, others
		Automatic Crude Blending	.....	$230,000	Under Constr	1960	.....	Staff	Staff
		*Hydrodesulfizer	.....	$1,200,000	Complete	.....	.....	.....	.....
SunOlin Chemical	North Claymont, Del.	Urea	200 tons	$8,000,000	Complete	.....	.....	Kellogg/Staff	Kellogg
		*Exp. Ethylene, Ethylene Oxide, Ethylene Glycol	200,000 lbs/yr	$15,000,000	Engineering	.....	.....	.....	.....
Tennessee Eastman	Kingsport, Tenn.	High-Purity Hydrogen	900 Mcf	.....	Under Constr	Early 1960	.....	Girdler	Girdler
Union Carbide Chemicals	Institute, W. V.	Exp. Acrylonitrile	.....	.....	.....	.....	.....	.....	.....

Mid-Continent

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Ashland O & R	Canton, Ohio	Gas Revamp	.....	.....	Planning	Dec 1960	.....	.....	.....
Aurora Gasoline	Detroit	Vacuum Distl.	18,000 bbls	.....	Under Constr	1960	.....	Treco	Treco
		Naphtha Unifining	8,000 bbls	.....	Under Constr	1960	UOP	Treco	Treco
		*Sulfuric Acid Alkylation	.....	.....	Complete	.....	.....	Treco	Treco
Borden Chemical	Illiopolis, Ill.	*Polyvinyl Chloride	40,000,000 lbs/yr	$4,000,000	Planning	.....	.....	.....	.....
Century Refining	Garden City, Kan.	Catalytic Cracking	3,000 bbls	.....	Under Constr	May 1960	Socony	Litwin	Litwin
		Gas Concentration	.....	.....	Under Constr	May 1960	.....	Litwin	Litwin
		C_3-C_4 HF Alkylation	800 bbls	.....	Under Constr	May 1960	Phillips	Litwin	Litwin
Cooperative Farm Chemicals	Lawrence, Kan.	Ammonia	100 tons	$5,400,000	Under Constr	1960	.....	Chemico	Chemico
		Urea	30 tons						
		Nitric Acid	130 tons	$1,250,000	Complete	.....	.....	Chemico	Chemico
Dow Chemical	Midland, Mich.	*Exp. Styrene Monomer	.....	.....	Planning	Late 1960	.....	.....	.....
Du Pont	Circleville, Ohio	Polyester	.....	.....	Under Constr	Early 1960	.....	.....	.....
Goodyear Tire & Rubber	Akron, Ohio	Exp. Extruded Polyvinyl Chloride	.....	.....	Planning	.....	.....	.....	.....
Great Northern Oil	Pine Bend, Minn.	Sulfuric Acid Alklation	2,000 bbls	.....	Under Constr	Fall 1960	UOP	Treco	Treco
Gulf Oil	Cleves, Ohio	Distillate Treater	11,000 bbls	.....	Under Constr	1960	UOP	McKee	McKee
	Toledo, Ohio	Distillate Treater	16,000 bbls	.....	Under Constr	1960	Petrico	Staff/Kaighin-Hughes	Staff/Kaighin-Hughes
		Crude and FCCU Revamp	.....	.....	Under Constr	1960	Gulf/Kellogg	.....	Kaighin-Hughes/Kellogg
Kerr-McGee	Wynnewood, Okla.	Exp Crude	25,000 bbls	.....	Complete	.....	.....	Litwin	Kaighin-Hughes/Litwin
		Vacuum Distl	10,625 bbls	.....	Complete	.....	.....	Litwin	Kaighin-Hughes/Litwin
		FCCU Revamp, TEL Blending	.....	.....	Under Constr	Feb 1960	.....	Litwin	Kaighin-Hughes/Litwin
Lion Oil, Division of Monsanto	El Dorado, Ark.	Unifiner—Platformer	5,000 bbls	.....	Engineering	.....	UOP	UOP/Procon	Procon
		*Exp. Refinery:							
		Vacuum Distl	1,400 bbls						
		Catalytic Cracking	2,500 bbls						
		Reformer	1,300 bbls						
		Sulfuric Acid	600 bbls		Complete	.....	.....	.....	Staff
		Alkylation	.....						
		Catalytic Polymerization	250 bbls						
		Straight-Run Basic Asphalt	100 bbls						
		*Sulfur Recovery	15 tons	.....	Under Constr	June 1960	.....	Staff	Staff
Monsanto Chemical	Monsanto, Ill.	*Exp. Phenol	.....	.....	Under Constr	Mid 1961	.....	.....	.....
	El Dorado, Ark.	Urea Distl.	.....	.....	Under Constr	.....	.....	Chemico	Chemico
	St. Louis	Exp. Maleic Anhydride	20,000,000 lbs/yr	.....	Planning	Mid 1960	.....	SD	SD
National Cooperative Refining	McPherson, Kan.	*Naphtha Unifiner	8,000 bbls	$800,000	Under Constr	July 1960	UOP	Staff/UOP	Treco
Northwestern Ref.	St. Paul Park, Minn.	Cat Reformer	.....	.....	Planning	1960	.....	.....	.....
Ohio Oil	Pulaski, Mich.	Natural Gasoline	25 MMcf	.....	Under Constr	Mid 1960	.....	.....	.....

*First appearance in tabulation.

CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Phillips Petroleum	Kansas City, Kan.	Alkylation	6,600 bbls	.....	Complete	.....	Phillips	Phillips	Procon
Reichhold Chemicals	Detroit	Formaldehyde	35,000,000 lbs/yr	.....	Planning	.....	Staff	Staff	Staff
RJ Oil & Refining	Princeton, Ind.	Unifiner	1,700 bbls	.....	Planning	.....	.....	.....	.....
		Crude Distl.	5,000 bbls	.....	Under Constr	1960	.....	.....	.....
		Platformer	1,700 bbls	.....	Planning	.....	.....	.....	.....
Shell Oil	Wood River, Ill.	Catalytic Reformer & Offsite Facilities	25,000 bbls	$15,000,000	Under Constr	Aug 1960	.....	McKee/Parsons	McKee/Parsons
	Healdton, Okla.	Exp. Plant	.....	$315,000	Under Constr	.....	.....	Staff	Hudson
Skelly Oil	El Dorado, Kan.	Gasoline Treater	7,000 bbls	.....	Complete	.....	.....	Litwin	Staff
St. Paul Ammonia Products	Pinex Bend, Minn.	*Compressor, Auxilliary Facil	53 tons	$500,000	Under Constr	April 1960	.....	Tolts, King Duvall & Asso	Quamco
Standard-Indiana	Whiting, Ind.	Vapor Recovery	.....	.....	Under Constr	1960	.....	McKee	McKee
		Exp. Cat Cracker	10,000 bbls	.....	Engineering	1960	.....	Kellogg	Staff
		Alkylation	11,400 bbls	.....	Engineering	1961	.....	Bechtel	Bechtel
Standard-Ohio	Lima, Ohio	Acrylonitrile	.....	.....	Under Constr	1960	.....	Badger Mfg	Badger Mfg
	Cleveland	*Pilot Plant, Research Center	170% Increase	.....	Complete	.....	.....	Staff	Staff
Sun Oil	Toledo	Automatic Tank Gauging	.....	$200,000	Under Constr	Spring 1960	.....	Staff	Staff
Sunray Mid-Continent	Purcell, Okla.	Exp. Natural Gasoline	25 MMcf	$600,000	Engineering	June 1960	.....	Staff/Tuloma	.....
Union Carbide	Marietta, Ohio	Bisphenol-A	25,000,000 lbs/yr	.....	Under Constr	Early 1961	.....	.....	.....
	Whiting, Ind.	Low-density Polyethylene	72,000,000 lbs/yr	.....	Under Constr	1960	.....	.....	.....
U.S. Rubber	Painesville, Ohio	*Exp. Vinyl Resins	to 65,000,000 lbs/yr	.....	Under Constr	July 1960	.....	.....	.....
Vickers	Potwin, Kan.	Water Disposal	.....	$200,000	Under Constr	1960	.....	Wilson	Sherwood/ Litwin
Western Petrochemicals	Chanute, Kan.	Waste Disposal	.....	.....	Engineering	1960	.....	Litwin	Litwin
		Vacuum Distl.	500 bbls	.....	Engineering	1960	.....	Litwin	Litwin
		Propane Desasphalting	350 bbls	.....	Engineering	1960	.....	Litwin	Litwin
Witco Chemical	Chicago	Phthalic Anhydride	20,000,000 lbs/yr	.....	Under Constr	1960	S D	S D	S D

Southwest

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Allied Chemical	Orange, Texas	*Polyethylene Glycol	.....	.....	Under Constr	.....	.....	.....	.....
Amarillo Oil/Texaco	Pampa, Texas	Natural Gasoline	60 MMcf	.....	Under Constr	April 1960	.....	Dresser	Dresser
American Oil	Texas City	Relocated Delayed Coker	430 tons	.....	Planning	1960	.....	Tellepsen	Tellepsen
Bay Petroleum	Chalmette, La.	Alkylation	2,700 bbls	.....	Under Constr	Early 1960	UOP	Bechtel	Bechtel
		Exp Cat Cracker	15,000 bbls	.....	Under Constr	Early 1960	UOP	UOP	Procon
		Crude	35,000 bbls	.....	Under Constr	Early 1960	.....	Bechtel	Bechtel
Carbide & Carbon	Seadrift, Texas	Exp. Ethylene Oxide	To 200,000,000 lbs/yr	.....	Planning	.....	.....	.....	.....
Carwin	Houston	*Special Isocyanates	500,000 lbs/yr	$1,500,000	Engineering	Late 1960	.....	Pona Engineers	Pona Constructors
	Texas City	Exp. Polyethylene	.....	.....	Engineering	.....	.....	B&R	.....
		Exp. Ethylene Glycol	65 MMcf	.....	Planning	.....	.....	.....	.....
Celanese Plastics	Houston	*Exp. High-Density Polyetyhlene	10,000,000 lbs/yr	.....	Complete	.....	.....	.....	.....
Champlin Oil & Refining	Enid, Okla.	Exp. Cat Cracker	20,000 bbls	.....	Under Constr	1960	Kellogg	Staff/Kellogg	Staff
		Exp. Alkylation	2,000 bbls	.....	Under Constr	1960	Kellogg	Staff/Kellogg	Staff
Chemoil	Louisiana	*Refinery	40,000 bbls	$40,000,000	Planning	.....	.....	Lummus	Lummus
Cimarron Transmission	Love County, Okla.	*Gas Treating	40 MMcf	$300,000	Under Constr	May 1960	.....	Pona Engineers	Pona Constructors
Coastal Products	Corpus Christi, Texas	*Delayed Coking	7,000 bbls	$3,000,000	Under Constr	.....	.....	Treco	Treco
Continental Oil	Lake Charles, La.	*Straight-Chain Primary Alcohols	50,000,000 lbs/yr	.....	Under Constr	Early 1961	.....	.....	.....
		*Cat Reformer	11,000 bbls	$3,000,000	Under Constr	.....	.....	Bechtel	Bechtel
	Ponca City, Okla.	*Cyclohexane	20,000,000 gals/yr	$1,000,000	Under Constr	Sept. 1960	.....	.....	Procon
	Reeves County, Texas	*Natural Gasoline	65,000 gals	.....	Under Constr	May 1960	.....	Russell Engineering	Russell Engineering
Copolymer Rubber & Chemical	Baton Rouge	Exp. Butadiene	35,000 tons/yr	.....	Under Constr	.....	.....	.....	.....
Cosden Petroleum	Big Spring, Texas	*Exp. Styrene	to 60,000,000 lbs/yr	.....	Engineering	.....	UOP	Badger Mfg	Badger Mfg
		*Desulfurization	6 MMcf	$200,000	Engineering	August 1960	.....	Graff	Badger Mfg
		*Ortho-Xylene	70,000,000 lbs/yr	.....	.....	Early 1961	.....	.....	.....
CM&M Gas Products	Wise County, Texas	Exp. Gas Processing, Liquid Recovery	150 MMcf	$700,000	Under Constr	1960	.....	.....	.....
Delhi-Taylor	Corpus Christi, Texas	*Ortho-Xylene Fractionation	3,000,000 gals/yr	.....	Under Constr	July 1960	.....	Staff/UOP	Staff
Dow Badische Chemical	Freeport, Texas	*Acrylic Monomer	.....	.....	Complete	.....	Staff	.....	.....
Dow Chemical	Freeport, Texas	Acrylonitrile	.....	.....	Planning	.....	.....	.....	.....
		Styrene-Butadiene Latexes	.....	.....	Engineering	1961	.....	.....	.....
		Anhydrous Ammonia	.....	.....	Planning	Early 1960	.....	.....	.....
		*Exp. Ethylene 67%	.....	.....	Engineering	1961	.....	.....	.....
		*Exp. Styrene Monomer	.....	.....	Planning	.....	.....	.....	.....
	Plaquemine, La.	Polyethylene	.....	$12,000,000	Under Constr	Late 1960	ICI	.....	.....
		Vinylidene Chloride	.....	.....	.....	.....	.....	.....	.....
		Methyl Chloriform	.....	.....	.....	.....	.....	.....	.....
Du Pont	Orange	Polyethylene	.....	.....	Under Constr	.....	.....	.....	.....
	Beaumont	Caprolactam	50,000,000 lbs/yr	.....	Planning	Late 1960	.....	Staff	Staff
		Acrylonitrile	.....	.....	Under Constr	Spring 1961	Staff	Staff	Staff
DX Sunray	Tulsa	*MEK, Solvent Dewaxing & Deoiling	5,835 bbls	$7,500,000	Under Constr	Sept 1960	Texaco	Foster Wheeler	Foster Wheeler
		*Benzene Udex	600 bbls	$1,500,000	Under Constr	Oct 1960	UOP	Treco	Treco
		*Crude	85,000 bbls	.....	Planning	Summer 1961	.....	.....	.....
	Duncan, Okla.	*Cat Cracker Revamp	.....	$600,000	.....	.....	.....	.....	Treco
Eastern States Petroleum & Chem.	Houston	*Exp. Refinery	.....	.....	Planning	.....	.....	.....	.....
El Paso Natural Gas	Terrell County, Texas	Treating	220 MMcf	$4,827,000	Planning	.....	.....	.....	.....
El Paso Natural Gas Products	Odessa, Texas	*Exp. Styrene	to 60,000,000 lbs/yr	.....	Under Constr	July 1960	.....	Staff	Staff
Esso Standard	Baton Rouge, La.	*Exp. Butyl Rubber, Stage I	20,000 tons/yr	$8,000,000	Under Constr	Mid 1960	.....	.....	.....
		*Exp. Butyl Rubber, Stage II	18,000 tons/yr	$8,000,000	Under Constr	Mid 1961	.....	.....	.....
Ethyl	Houston	*Vinyl Chloride Monomer	.....	.....	Under Constr	Early 1961	.....	.....	.....
Firestone	Orange, Texas	Polyisoprene, Polybutadiene	30,000 tons/yr	.....	Engineering	.....	.....	.....	.....
Goliad/Union Oil of Cal.	Vermillion Parish, La.	Natural Gasoline	450 MMcf	$4,000,000	Planning	.....	.....	Fluor	Fluor

*First appearance in tabulation.

Construction BOXSCORE continued on Page 260

CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Goodrich Gulf Chemicals	Port Neches, Texas	*Polyolefins, High-Density Polyethylene	13,000,000 lbs/yr	.....	Under Constr	Late 1960	Ziegler	Parsons	Parsons
Gulf Oil	Port Arthur	Deisobutanizer	10,000 bbls	.....	Under Constr	1960	.....	Treco	Treco
		High Purity Ethylene	1,400,000 lbs	.....	Engineering	Summer 1960	.....	Kellogg/Gulf	Kellogg/Gulf
		Oxo Preparation	.....	.....	Under Constr	1960	.....	Staff/Treco	Treco
Hercules Powder	Lake Charles, La.	*Polypropylene	100,000,000 lbs/yr	.....	Under Constr	1961	Staff	.....	.....
Houston Chemical	Beaumont, Texas	*Ethylene Glycol	8–12,000,000 gals/yr	$12,000,000	Engineering	1961	.....	.....	.....
Howell Refining	Corpus Christi, Texas	*Exp. Refinery	1,500 bbls	.....	Complete	.....	.....	.....	.....
Humble	Baytown, Texas	Polyolefin	40,000 lbs/yr	.....	Under Constr	1960	.....	Esso	Staff
		Exp Lube Hydrofiner, Dewaxing, Extraction	9,500 bbls	.....	Planning	Late 1960	.....	.....	.....
	Kleberg County, Texas	Gas Process & Cycling	800 MMcf	.....	Under Constr	1960	.....	Staff	Hudson
Hunt Oil	Alta Loma, Texas	Natural Gasoline	.....	.....	Planning	.....	.....	Hudson	Hudson
Jefferson Chemical	Conroe, Texas	*Morpholine, Polyurethane Resin Intermediates, Speciality Surface-Active Agents	.....	.....	Planning	Mid 1960	.....	.....	.....
Jefferson Lake Sulfur	Greens Bayou, Texas	*Exp. Distillation	.....	$180,000	Under Constr	April 1960	.....	Hedrick/B & R	B & R
		*Storage	.....	$70,000	Under Constr	April 1960	.....	Merichem	Baker Tank
Koppers	Port Arthur	Exp. Polyethylene	.....	.....	Under Constr	1960	Staff	Staff	Staff
La Gloria Oil & Gas	Arcadia Parish, La.	LPG	176 MMcf	.....	Under Constr	Early 1960	.....	B & R	B & R
		Natural Gasoline							
Midland Cooperatives	Cushing, Okla.	*C_3C_4 HF Alkylation	1,300 bbls	$1,200,000	Under Constr	April 1960	UOP	UOP/Procon	Procon
Mobil Oil	Beaumont, Texas	Exp. Catalytic Reforming	20,000 bbls	.....	Under Constr	1960	.....	Fluor	Fluor
		Ethylene	380,000,000 lbs/yr	.....	Under Constr	1961	.....	Kellogg	Kellogg
		Exp. Polyethylene	12,500 bbls	$2,500,000	Planning	.....	.....	.....	.....
Monsanto Chemical	Gulf Coast	*Styrene Monomer	200,000,000 lbs/yr	$30,000,000	Planning	Early 1961	.....	.....	.....
	Luling, La.	*Ammonia	.....	.....	Complete	.....	.....	.....	Dresser
Northern Natural Gas	Spearman, Texas	*Exp. Natural Gasoline	to 200 MMcf	.....	Under Constr	July 1960	.....	.....	.....
Pan American Pet.	North Cowden, Texas	Exp. Gas Compression	.....	.....	Under Constr	1960	.....	Staff	B & R
	Old Ocean, Texas	Exp. Refinery	.....	.....	Engineering	Late 1960	.....	B & R	B & R
Petroleum Chemicals	Lake Charles, La.	*Exp. Ethylene	100,000,000 lbs/yr	.....	Under Constr	.....	.....	Lummus	.....
Phillips Chemical	Borger, Texas	Multi-Purpose Chemicals	.....	.....	Under Constr	1960	.....	Staff	Staff
		*Exp. Synthetic Rubber	20,000 tons/yr	.....	Under Constr	August 1960	.....	.....	.....
		*Cis-4 Polybutadiene	20,580 tons/yr	.....	Engineering	1960	.....	Staff	Staff
	Pasadena, Texas	Exp. Methylvinylpyridine	.....	.....	Complete	.....	.....	Staff	Staff
	Sweeny, Texas	Exp. Ethylene	.....	.....	Under Constr	1960	.....	Staff	Staff
Phillips Petroleum	Sweeny, Texas	Hexane Isomerization	1,000 bbls	.....	Under Constr	1960	.....	Staff	Staff
	Orange, Texas	*Carbon Black	60,000,000 lbs/yr	.....	Under Constr	1960	.....	Staff	Staff
	Borger	Heavy Oil Cat Cracking	25,000 bbls	.....	Planning	Early 1961	.....	Kellogg	Kellogg
Runnels Gas Products/Texas Gas Exploration	Eunice, La.	*Exp. Extraction	to 800 MMcf	.....	Planning	Jan 1961	.....	Fluor	Fluor
Shamrock Oil & Gas	Sunray, Texas	Catalytic Cracking	8,000 bbls	.....	Complete	.....	.....	Fluor	Fluor
Shell Oil	Deer Park, Texas	Distillate Hydrotreater & Offsite Facilities	30,000 bbls	$3,500,000	Under Constr	Mid 1960	.....	Fluor	Fluor
	Norco, La.	*Asphalt Blender, Storage Tanks, Steam Generator	.....	.....	Under Constr	.....	.....	.....	.....
	Sheridan, Texas	Gas Cycling	150 MMcf	$1,000,000	Planning	Late 1960	.....	.....	.....
Shell Chemical	Norco, La.	Acrolein	.....	.....	Under Constr	.....	.....	.....	.....
		Glycerine	.....	$4,500,000	Under Constr	1960	.....	Staff	Parsons/Fluor
Sinclair-Koppers	Houston	*Styrene Monomer	70,000,000 lbs/yr	.....	Under Constr	Mid 1961	.....	.....	.....
Sinclair Refining	Hulldale Field, Texas	Desulfurizer	.....	.....	Under Constr	.....	.....	.....	.....
South Louisiana Production	Jeanerette, La.	Butane, Propane, Other LPG	.....	.....	Under Constr	.....	.....	.....	.....
Spencer Chemical	Orange, Texas	Exp. Polyethylene	120–135,000,000 lbs/yr	.....	Under Constr	Summer 1960	.....	Staff	Quaker Valley
Sunray Mid-Continent	Bossier Parrish, La.	Exp Recovery Facilities	500 MMcf	$500,000	Planning	Sept 1960	.....	.....	.....
Suntide Refining	Corpus Christi, Texas	*Delayed Coking	7,000 bbls	.....	Complete	.....	.....	Treco	Treco
Texas Eastman	Longview, Texas	Exp. Oxo, Normal Butyraldehyde, Iso-butyraldehyde	125,000,000 lbs/yr	.....	Complete	.....	.....	Staff	Hudson
		*Polypropylene	20,000,000 lbs/yr	.....	Under Constr	Mid 1960	.....	Staff	Hudson
Texas Alkyls	Houston	Detergents	.....	.....	Under Constr	Late 1960	.....	Staff	B & R
		*Aluminum Trialkyls	1,000,000 lbs/yr	.....	Complete	.....	Ziegler	.....	.....
		*Ethyl Aluminum Sesquichloride, Diethyl Aluminum Chloride, other Aluminum Hydrides, Higher Aluminum Trialkyls	.....	.....	Planning	1961	.....	.....	.....
Texas Natural Gasoline	Arcadia, Parish, La.	Natural Gas Liquids	.....	.....	Under Constr	Early 1960	.....	Fluor	Fluor
Texas-U.S. Chemical	Port Neches, Texas	*Exp. Carbon Black-Synthetic Rubber 10%	to 156,000 tons/yr	.....	Under Constr	Late 1960-Early 1961	.....	Tellepsen Petro-Chem Constructors	.....
Tidewater Oil	Franklin County Texas	Cycling	50 MMcf	.....	Under Constr	Early 1960	.....	B & R	B & R
		Natural Gasoline	250 tons	.....	Engineering	Early 1960	.....	B & R	B & R
		Sulfur Recovery	75 MMcf	$1,500,000	Under Constr	Late 1960	.....	Olsen	Olsen
	Houma, La.	Natural Gasoline	180 MMcf	.....	Complete	.....	Giammarco-Vetrocoke	B & R	B & R
Transwestern Pipeline	Ft. Stockton Texas	Gas Treating							
Union Carbide	Seadrift, Texas	Ester & Alcohol	100,000,000 lbs/yr	.....	Engineering	1960	.....	.....	.....
		Exp. Petrochemicals	.....	.....	Under Constr	1960	.....	Staff	B & R
	Brownsville, Texas	Chemical Solvents, Intermediates	.....	.....	Under Constr	March 1961	.....	.....	.....
United Rubber & Chemical	Baytown, Texas	Synthetic Rubber	.....	.....	Under Constr	.....	.....	Day & Zimmerman	Tellepsen
U.S. Industrial Chemicals	Houston	Exp. Polyethylene	100,000,000 lbs/yr	.....	Under Constr	Mid 1960	ICI	Kellogg	Kellogg
Warren Petroleum	Fashing, Texas	Sulfur Recovery	50 long tons	$500,000	Engineering	July 1960	.....	Graff Engineering	Delta Engineering
Western Nat. Gas	Brownsville, Texas	Refinery Revamp	3,500 bbls	.....	Under Constr	.....	.....	.....	Staff
		*Exp. Refinery	12,500 bbs	$2,500,000	Planning	.....	.....	.....	.....
	Edinburg, Texas	Gas Processing	60 MMcf	.....	Under Constr	May 1960	.....	Tuloma Builders	Tuloma Builders
	Nursery, Texas	Gas Processing	10 MMcf	.....	Engineering	July 1960	.....	.....	.....
Wickett Refining	Wickett, Texas	*Platformer	1,500 bbls	$350,000	Planning	Nov 1960	UOP	J C Hinds	J C Hinds

• First appearance in tabulation.

Rocky Mountain

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
American Gilsonite	Grand Junction, Colo.	*Exp. Coking	1,100 tons	.....	Planning	.....	.....	.....	.....
El Paso Natural Gas	Jal, N.M.	Exp. Natural Gasoline	210 MMcf	$1,266,000	Under Constr	April 1960	.....	Dresser	Dresser
Farmers Union Central Exchange	Laurel, Mont.	*Unifiner	7,100 bbls	.....	Under Constr	May 1960	.....	.....	.....
Husky Oil	Cody, Wyo.	Refinery	9,000 bbls	.....	Under Constr	.....	.....	.....	.....
Pan American Petroleum/Hondo Oil & Gas	Eddy County, N.M.	Natural Gasoline, Sulfur Recovery	15 MMcf	.....	Under Constr	Mid 1960	.....	Olsen	Olsen
Phillips	Artesia, N.M.	Natural Gasoline	35 MMcf	.....	Under Constr	Fall 1960	.....	.....	.....
Southwestern Nitrochemical	Chandler, Ariz.	Ammonia Synthesis	80 tons	$4,000,000	Complete	.....	.....	Chemico	Chemico
Texaco	Casper, Wyo.	Hydrotreater	4,500 bbls	.....	Engineering	August 1960	.....	Texaco	Badger
Utah Oil Refining	Salt Lake City, Utah	*Exp. Cat Cracker, Alkylation, Tankage, Water Treating	.....	$1,500,000	Planning	1960	.....	.....	.....

West Coast

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Allied Chemical	El Segundo, Cal	*Ammonium Sulfate	56,000 tons/yr	.....	Under Constr	Late 1960	.....	.....	.....
American Chemical	Long Beach, Cal.	*Ethyl Chloride, Ethylene Dichloride, Vinyl Chloride, Monomer, Vinyl Chloride Polymer	.....	.....	Complete	.....	.....	.....	.....
Borden Chemical	San Francisco	*Resins	25,000 tons/yr	.....	Under Constr	.....	.....	.....	.....
		*Formaldehyde	22,500 tons/yr	.....	Under Constr	.....	.....	.....	.....
California Ammonia	Lathrop, Cal.	Ammonia Synthesis	100 tons	$5,000,000	Engineering	1960	.....	Macco	Macco
Collier Carbon & Chemical	Los Angeles	Sulfuric Acid	250 tons	.....	Engineering	Late 1960	Leonard/Monsanto	Braun/Leonard/Monsanto	.....
		Ammonium Sulfate	150 tons	.....	Engineering	Late 1960	.....	Ebhart	
	Rodeo, Cal.	Carbon Calcining	.....	.....	Under Constr	Fall 1960	.....	.....	.....
	Wilmington, Cal.	Sulfuric Acid	.....	.....	Engineering	Sept 1960	Monsanto	Braun/Leonard	Braun
Dow Chemical	Torrance, Cal.	Polypropylene	.....	.....	Planning	1961	.....	.....	.....
	Kalama, Wash.	*Phenol	36,000,000 lbs/yr	.....	Planning	Mid 1961	.....	.....	.....
Du Pont	Antioch, Cal.	Fluorinated Hydrocarbons, Tetraethyl Lead	.....	.....	Under Constr	.....	.....	.....	.....
B. F. Goodrich	Watson, Cal.	*Polyvinyl Chloride	.....	.....	Under Constr	Spring 1960	.....	S D	S D
Hercules Powder	Hercules, Calif.	*Methanol	8,000,000 gals/yr	.....	Under Constr	Early 1961	.....	.....	.....
		*Urea-Formaldehyde Compositions	11,000 tons/yr	.....	Under Constr	Mid 1960	.....	.....	.....
		*Formaldehyde	50,000,000 lbs/yr	.....	Under Constr	Early 1961	.....	.....	.....
Mobil Oil	Torrance, Cal.	Exp Delayed Coker	9,300 bbls	.....	Complete	.....	.....	Bechtel/Staff	Bechtel
Oronite Chemical	Richmond, Cal.	*Malerie Anhydride	20,000,000 lbs/yr	.....	Under Constr	Mid 1960	.....	Badger Mfg	Badger Mfg
Richfield Oil	Everett, Wash.	*Refinery	.....	$50,000,000	Planning	1965	.....	.....	.....
Shell Development	Emeryville, Cal.	Research Lab.	.....	$500,000	Under Constr	.....	.....	.....	.....
Signal Oil & Gas	Bakersfield, Cal.	Exp. Refinery	20,000 bbls	.....	Under Constr	Late 1960	.....	Parsons	Parsons
Standard Oil (Calif)	Richmond, Cal.	Maleic Anhydride	20,000,000 lbs/yr	.....	Under Constr	Mid 1960	.....	Badger	Badger
		*Polymers	.....	.....	Planning	.....	.....	.....	.....
	Everett, Wash.	*Refinery	60,000 bbls	$75,000,000	Under Constr	.....	.....	.....	.....
	Honolulu	Refinery	35,000 bbls	$40,000,000	Under Constr	1961	.....	Staff/Bechtel	Bechtel/Hawaiian Dredging
Texaco	Wilmington, Cal.	*Catalytic Reformer	12,000 bbls	.....	Under Constr	June 1960	.....	.....	.....
		*Hydrotreater	12,000 bbls	.....	Under Constr	June 1960	.....	.....	.....
Union Oil	Wilmington, Cal	Catalytic Reformer	14,000 bbls						
		Mid-Barrel Unifiner	20,000 bbls	$17,000,000	Under Constr	Fall 1960	Staff	Braun	Braun
		Heavy Cat Unifiner	4,000 bbls						
		Diesel-Oil Unifiner	10,000 bbls						
		*Gasoline Blending, Offsite Exp.	.....	$1,500,000	Engineering	.....	.....	Fluor	Fluor
		CO Boiler	240,000 lbs/hr	$2,500,000	Engineering	Late 1960	.....	Fluor	Fluor
		Amine Reactivator	150 tons	$1,600,000	Engineering	Spring 1960	.....	Parsons	Parsons
		H_2S Recovery	.....	.....	.....	.....	.....	.....	.....
Valley Nitrogen	Helm, Cal.	Ammonia	150 tons	.....	Engineering	1960	Chemico	Chemico	Chemico
Wilshire	Santa Fe Springs, Cal.	Alkylation	1,500 bbls	.....	Engineering	Spring 1960	UOP	UOP/Braun	Staff/Braun

Canada

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
British American Oil	Clarkson, Ont.	Compounding, Blending & Grease	.....	$2,900,000	Under Constr	.....	.....	Nofsinger	Foster Wheeler
		Alkylation	3,000 bbls	$3,000,000	Under Constr	1960	UOP	UOP	Procon
	Calgary	Exp. Reformer	3,000 bbls	$500,000	Complete	.....	.....	Treco	Terco
		*Exp. Combination, Crude Topping, Vacuum & Thermal Cracking	to 10,000 bbls	.....	Under Constr	1960	.....	.....	.....
	Moose Jaw Sask.	Cat Reformer	5,400 bbls	.....	.....	.....	.....	.....	.....

*First appearance in tabulation.

Construction BOXSCORE continued on Page 262

CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
British American Oil, et al	Rimbey, Alb.	*Gas Processing	326 MMcf	$10,000,000	Under Constr	Nov 1960	.....	Poole-Pritchard Canadian	Poole-Pritchard Canadian
British Petroleum	Ville d'Anjou	Crude Distl	25,000 bbls	.....	Under Constr	Spring 1960	.....	Lummus	Lummus
		Cat Cracker	9,000 bbls	.....	Under Constr	Spring 1960	UOP	Lummus	Lummus
		Platformer	6,000 bbls	.....	Under Constr	Spring 1960	UOP	Lummus	Lummus
		Cat Desulfuriser	12,000 bbls	.....	Under Constr	Spring 1960	.....	Lummus	Lummus
		Cat Polymerization	700 bbls	.....	Under Constr	Spring 1960	UOP	Lummus	Lummus
Canadian Chemicals	Edmonton, Alb.	*Revamp Petrochemicals	.....	$4,000,000	Engineering	Jan 1961	.....	Staff/B & R	Staff/B & R
		*Exp. Refinery	.....	$4,000,000	Planning	.....	.....	.....	.....
Canadian Oil	Carunna, Ont.	Unifiner	5,000 bbls	.....	Under Constr	1960	.....	UOP	Procon
	Bowden, Alb.	*Refinery	4,500 bbls	$4,000,000	Under Constr	Fall 1960	UOP	Bechtel	Bechtel
Carbide Chemicals	Montreal East, Quebec	*Exp. Ethylene Oxide, Oxide Derivatives 100%	.....	.....	Under Constr	Early 1961	.....	.....	.....
		*Exp. Polyethylene	to 65,000,000 lbs/yr	.....	Under Constr	Late 1960	.....	.....	.....
Carstairs Operators Committee	Carstairs, Alb.	Gas Processing	66 MMcf	$3,500,000	Under Constr	Spring 1960	.....	Fluor	Fluor
Consolidated Mining & Smelting	Calgary, Alb.	*Urea	100 tons	$5,000,000	Under Constr	Mid 1960	Inventa-Vulcan	Vulcan/Braun	Comineo/Braun
Consumers Cooperative Refineries	Regina, Sask.	*Naphtha Unifiner	3,000 bbls	.....	Under Constr	.....	.....	.....	.....
		*Platformer	3,000 bbls	$2,500,000	Engineering	Nov 1960	UOP	Staff/UOP	.....
Cyanamid of Canada	Welland, Ont.	Nitric Acid	190 tons	.....	Engineering	1960	Uhde	McKee	McKee
Imperial Oil	Edmonton, Alb.	Alkylation	1,500 bbls	$2,175,000	Engineering	1960	.....	.....	.....
	Regina	Powerformer	3,000 bbls	$2,550,000	Under Constr	1960	.....	Canadian Kellogg	Canadian Kellogg
Innisfail Operators Committee	Innisfail Field, Alb.	Refinery	10,000 bbls	.....	Planning	.....	.....	.....	.....
		Sulfur Recovery	80 tons	.....	Planning	.....	.....	.....	.....
		Gas Treating	8.7 MMcf	.....	Planning	.....	.....	.....	.....
Irving Refining	St. John, New Brunswick	Hydrogen	.....	.....	Engineering	1960	.....	Girdler Bechtel	Canadian Bechtel
		Crude Desalter	38,500 bbls	.....	Under Constr	1960	Howe-Baker	Bechtel	Bechtel
		Gas Treating-Sulfur Recovery	.....	.....	Engineering	1960	.....	Parsons	.....
		Refinery:							
		*Two-Stage Crude	40,000 bbls						
		*Catalytic Cracker	13,000 bbls						
		*Catalytic Reformer	7,150 bbls	$45,000,000	Under Constr	1960	.....	Canadian Bechtel	Canadian Bechtel/Fluor
		*Hydrodesulfurization	5,000 bbls						
		*Hydrogen Treating	2,500 bbls						
Jefferson Lake Petrochemicals	Calgary, Alb.	*Sulfur Recovery	.....	.....	Under Constr	Nov 1960	.....	.....	.....
	Savannah Creek, Alb.	*Sulfur Recovery	.....	.....	Under Constr	.....	.....	.....	.....
Monsanto, Canada	Villa La Salle, Que.	Maleic Anhydride	6,000,000 lbs/yr	.....	Planning	Late 1960	.....	SD	SD
Nevis Operators Committee	Nevis, Alb.	Gas Processing	43 MMcf	$3,000,000	Under Constr	1960	.....	Fluor	Fluor
		Sulfur Recovery	125 tons						
Nottingham Gas Carnduff Gas	Saskatchewan	Gas Processing, Treating, Gathering	8.5 MMcf	.....	Engineering	1960	.....	Tellepsen	Tellepsen
Polymer	Red Deer, Alb.	*Butadiene	30,000 tons/yr	$15,000,000	Planning	.....	.....	.....	.....
Phillips Petroleum	Taylor, B.C.	Refinery	.....	.....	Under Constr	1960	.....	Stearns Roger	Stearns Roger
Regent Refining	Port Credit, Ont.	*Catalytic Reformer	4,700 bbls	$1,500,000	Engineering	Fall 1960	.....	UOP	Catalytic
Shell Oil (Canada)	Bronte, Ont.	Refinery	20,000 bbls	.....	Planning	.....	.....	.....	.....
Sogenines	Maitland, Ont.	Synthetic Nitrogen, Ammonium Nitrate, Nitrogen Solutions, Anhydrous Ammonia	.....	$17,000,000	Planning	1961	.....	.....	.....
Texaco, Canada	Montreal	Sulfuric Acid Alkylation Feed Preparation and Treating	2,200 bbls	.....	Under Constr	.....	.....	Foster Wheeler	Foster Wheeler
		*Vacuum Flashing	30,000 bbls	.....	Under Constr	May 1960	.....	Staff	.....
Westcoast Transmission	Coleman, Alb.	Gas Processing	.....	$15,000,000	Planning	.....	.....	.....	.....

Latin America

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
ARGENTINA									
Argentine Government	Santa Fe	Naphtha Reforming	6,300 bbls	.....	Planning	.....	.....	.....	.....
	Mendoza	*Topping, Delayed Coking, Catalytic Cracking	28,300 bbls	$25,000,000	Under Constr	Nov 1961	.....	Kellogg	Kellogg
	Salta	*Naphtha Reforming	3,150 bbls	.....	Planning	.....	.....	.....	.....
	Buenos Aires	*Lube Oil	2,000 bbls	.....	Planning	.....	.....	.....	.....
	Campo Duran Field	*Lube Oil, Gasoline, Reforming	.....	.....	Planning	.....	.....	.....	.....
Carbometal	Mendoza	Polyvinyl Choride	4,500 tons/yr	.....	.....	.....	.....	.....	.....
		Acetylene	200 tons/yr	.....	.....	.....	.....	.....	.....
		Plastics	7,500 tons/yr	.....	Planning	.....	Monsanto	Monsanto	Monsanto
Monsanto	Buenos Aires	Phthalic Anhydride	.....	.....	Under Constr	.....	.....	Foster Wheeler	.....
BRAZIL									
Alba	Cubatao	Synthetic Methanol	30 tons	.....	.....	.....	Inventa/Vulcan	Vulcan-Cincinnati	Vulcan-Cincinnati
Industria Brasileira de Enxofre, S.A.	Copuava, Sao Paulo	Sulfur Recovery	25 long tons	$300,000	Under Constr	Early 1960	.....	Staff	Staff
North American Solvay	Sao Paulo	Ethylene Purification	20 tons	.....	Under Constr	1960	.....	Hydrocarbon	Hydrocarbon/SETAL
Petroleo Brasileiro	Mataripe	Atmospheric & Vacuum Distl. Cat Cracker, Gas Recovery Wax Treating, Lube	52,000 bbls	$30,000,000	Under Constr	1960	Kellogg	Kellogg	Kellogg Brasileira/Montreal, S A
	Pernambuco State	*Synthetic Rubber	40,000 tons/yr	.....	Planning	.....	.....	.....	.....
	Rio de Janeiro	Refinery	90,000 bbls	$60,000,000	Under Constr	1961	Houdry/UOP	Foster Wheeler	.....
	Duque De Caxias Estad. Do Rio de Janeiro	Synthetic Rubber	40,000 tons/yr	.....	Under Constr	1962	.....	Blaw Knox	.....
	Cubatao-Sao Paulo	Exp. Refinery	90,000 bbls	.....	Under Constr	1960	.....	Petrobras	.....
		Cat Reformer	12,000 bbls						
		Aromatics Extr.	3,000 bbls	$10,000,000	Engineering	Mid 1962	Houdry/UOP	.....	.....
		Ethane Cracking	3.77 MMcf						

*First appearance in tabulation.

CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
CEN. AMERICA									
Fertilizantes de Centro America (Ferticas), et al	Costa Rica	*Nitrogen, Potash & Phosphorous Fertilizers, Urea	650 tons	$10,000,000	Planning	.....	.....	.....	.....
Matias de Calves.....	Puerto Barrios	*Refinery	3,500 bbls	.....	Under Constr	.....	.....	Lummus	Lummus
Refineria Petrolera de Guatemala, et al	Matias, de Galves	*Refinery	12,000 bbls	.....	Planning	.....	.....	.....	.....
CHILE									
Empresa Nacional del Petroleo	**Concon**	**Refinery Exp:**							
		Crude Topping	**24,000 bbls**						
		Vacuum Distl	**10,080 bbls**						
		Orthoflow FCC	**12,000 bbls**	**$15,000,000**	**Complete**	.....	**Kellogg**	**Kellogg**	**Staff/Kellogg**
		SBK Cat Reforming and Desulfurization	**6,000 bbls**						
		Alkylation	**1,100 bbls**						
COLOMBIA									
Empresso Colombiana de Petroleos	**Barranca-Bermeja**	**Exp. Propane Recovery**	**1,000 bbls**	**$1,000,000**	**Planning**	.....	.....	.....	.....
	El Centro	Natural Gasoline	51.4 MMcf	$2,700,000	Under Constr	1960	.....	Parsons	Parsons
ECUADOR									
Anglo-Ecuadorian Oilfields	**Santa Elena**	**Atomspheric Distl.**	**7,700 bbls**	**$4,500,000**	Complete	.....	UOP	Procon	Procon
	Ancon	**Thermal Cracking**	**6,000 bbls**	.....	**Under Constr**	.....	UOP	Procon	Procon
GUATAMALA									
Breaux Oil Refining..	**Bridge Puerto Barrios**	Refinery	4,000 bbls	.....	Planning	.....	.....	Lummus	Lummus
MEXICO									
	La Venta & El Plan Fields	*Absorption	.....	.....	Under Constr	.....	.....	.....	.....
Pemex.....	Minatitlan	Anhydrous Ammonia,	200 tons	$8,000,000	Engineering	Late 1960	.....	Fluor	Fluor
		Crude, Cat Cracking, BTX	27,000 bbls	$23,000,000	Engineering	Mid 1961	UOP	Fluor	Fluor
	Atzcapotzal	*Exp. Alkylation	.....	.....	Under Constr	.....	.....	.....	.....
	Salamanca	Anhydrous Ammonia	200 tons	$8,000,000	Engineering	Late 1961	.....	Lummus	Lummus
		Cat Cracking, Exp. Refinery	20,000 bbls	$13,000,000	Engineering	Late 1961	Socony	Lummus	Lummus
		Grease	25 tons	$2,100,000	Engineering	Mid 1961	.....	McKee	McKee
Pemex.....	C. Madero	Topping, Cat Cracking Gas Recovery	110,000 bbls	$43,000,000	Under Constr	Mid 1960	Esso, UOP	McKee	McKee
	Poza Rica	Topping	15,000 bbls	$5,000,000	Under Constr	Late 1960	.....	McKee	McKee
		*Exp. Natural Gasoline	.....	.....	Under Constr	.....	.....	.....	.....
		*Refinery	.....	.....	Under Constr	.....	.....	.....	.....
	Reynosa	*Exp. Gas Absorption	.....	.....	Under Constr	.....	.....	.....	.....
NETHERLANDS ANTILLES									
Lago Oil & Transport	Aruba, N. A.	Revamp Distl. & Visbreaking	.....	.....	Complete	.....	.....	Kellogg	Kellogg
PANAMA									
Refiner a Petroquimica de Panama	**Portobelo**	**Refinery**	**55,000 bbls**	**$40,000,000**	**Engineering**	**1961**	.....	**Foster Wheeler**	**Foster Wheeler**
Refineria Panama, S A	**Las Minas Bay Colon**	**Refinery; Petrochemicals**	**70,000 bbls**	**$59,000,000**	**Under Constr**	**Late 1960**	.....	**Kellogg**	.....
PARAGUAY									
Compagnie Fives-Lille	**Asuncion, Paraguay**	**Refinery**	**10,000 bbls**	.....	**Planning**	.....	.....	.....	.....
PUERTO RICO									
Commonwealth Oil Refining	**Guayanilla Bay**	**Ref. Modifications**	**75,000 bbls**	**$6,300,000**	**Under Constr**	**1960**	.....	**UOP**	**Procon-Others**
TRINIDAD									
Federation Chemicals,	**Point Lisas**	**Ammonium Sulfate**	**245 tons**				**Stami-Carbon**	**Braun**	**Braun**
Texaco Trinidad.....	Pointe-a-Pierre	Crude Distl.	15,000 bbls	.....	**Under Constr**	.....	UOP	Procon	Procon
		Crude Topping	100,000 bbls	.....	Under Constr	Late 1960	.....	Fluor	Caribbean Bechtel
		Cat Reformer	15,000 bbls	.....	Under Constr.	Late 1960	.....	Fluor	Caribbean Bechtel
		Hydrotreater	20,000 bbls	.....	Under Constr	Late 1960	.....	Staff	Caribbean Bechtel
URUGUAY									
Administracion.....	Montevideo	Crude Desalter	28,000 bbls	$12,000,000	Under Constr	1960	Howe-Baker	Kellogg/Staff	
Nacional de Combustibles Alcohol Y Portland	La Teja	Vac. Distl.	10,000 bbls	.....	.....	.....	.....		
		Cat Cracker	5,000 bbls	.....	.....	.....	.....		
		Cat Reformer	3,000 bbls	.....	.....	.....	.....	Kellogg-/Staff	Staff
		Gas Concent. & Bottling	.....	.....	.....	.....	.....		
		Gas Sweetening	4,500 bbls	.....	.....	.....	.....		
		Sulfur Recovery	6 tons	.....	.....	.....	.....		
		Power & Offsite Facilities	3,600 kw	.....	.....	.....	.....		
		*CO Boiler	.....	.....	Under Constr	1960	.....	.....	.....
VENEZUELA									
CA Nacional de Grasas Lubricantes	Valencia	*Lube Grease	1,300,000 lbs/yr	.....	Complete	.....	.....	.....	.....
Cia Shell.....	**Cardon**	**Distl.**	**89,000 bbls**	**$20,000,000**	Complete	.....	.....	.....	.....
		Alkylation	2,800 bbls	.....	Complete	.....	.....	.....	.....
Mene Grande Oil.....	**Eastern Venezuela**	**Compressor Stations**	.....	.....	**Engineering**	**Early 1960**	.....	**B & R**	.....
Socony Mobil.....	**El Palito**	**Refinery**	**50,000 bbls**	**$28,000,000**	**Under Constr**	**1960**	.....	**Kellogg**	**Kellogg**
	Eastern Venezuela	Compressor Stations	.....	.....	Engineering	.....	.....	B & R	.....

Europe and Africa

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
AFRICA									
British Petroleum/ Shell Oil	Durban, Natal	*Refinery	.....	$70,000,000	Planning	1963	.....	.....	.....
Sociedade Nacional de Refinacao de Petroleos	Lourenco Marques, Mozambique	*Refinery:			Under Constr	Early 1961	.....	Procon	Procon
		Crude	12,000 bbls	.....	.....	.....	.....	.....	.....
		Platformer	2,500 bbls	.....	.....	.....	.....	.....	.....
		Diesel Fuel	2,000 bbls	.....	.....	.....	.....	.....	.....
		Unifiner	.....	.....	.....	.....	.....	.....	.....
		Merox	1,500 bbls	.....	.....	.....	.....	.....	.....
Standard-Vacuum Refining of So. Africa	Durban, Natal	*Exp. Asphalt	4,500 bbls	$415,000	Under Constr	1960	.....	Staff	Fraser & Chalmers S.A.
		*Continuous Oxidizer	300 bbls						

*First appearance in tabulation.

Construction BOXSCORE continued on Page 264

CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
AUSTRIA									
Oesterreich Mineraloelver-Waltung	Schwechat, Near Vienna	*Crude Distl	37,000 bbls.	.....	Under Constr	Late 1960	.....	Lurgi	Lurgi
		*Cat Reformer	7,000 bbls	.....	Under Constr	1961	UOP	Lurgi	Lurgi
		*Gas Recovery	14 MMcf	.....	Under Constr	1961	.....	Lurgi	Lurgi
		*Bitumin	3,200 bbls	.....	Complete	.....	.....	.....	.....
		*Cat Cracker	10,000 bbls	.....	Planning	.....	.....	.....	.....
Danubia Petrochemie A. G.	**Schwechat near Vienna**	**Polypropylene**	**11,000,000 lbs/yr**	.....	.....	.....	.....	.....	.....
BELGIUM									
Amoco Fina	Antwerp	Petroleum Additives	.....	.....	Planning	Early 1961	.....	.....	.....
AE & CI	Modderfontein	Synthetic Ammonia	70,000 tons	.....	Under Constr	1960	.....	Staff/ICI/ Power-Gas	Power-Gas
British Chrome & Chemicals	Urlay Nook	Sulfuric Acid	100 tons	.....	Under Constr	1960	Chemieban	Power-Gas	Power-Gas
Carbochimique	Tertre	Partial Oxidation Synthesis Gas	100-500 tons NH_3	.....	Under Constr	1960	Texaco	Power-Gas	.....
		High Pressure CO Conversion	100-150 tons NH_3	.....	Under Constr	1960	Texaco	Power-Gas	Power-Gas
Cobenam, S.A.	**Antwerp**	**Polyethylene**	**15,000 tons/yr**	.....	**Planning**	**Mid 1960**	.....	**Union Carbide**	**Union Carbide**
CANARY ISLANDS									
Cepsa	Las Palmas	Ammonium Sulfate	365 tons	.....	Engineering	Mid 1960	Uhde-Texaco	Uhde	Uhde
DENMARK									
Dansk Veedol	Kalundborg	Refinery	20,000 bbls	.....	Planning	1961	.....	.....	.....
ENGLAND									
British Petroleum	Isle of Grain	*Special Solvents	30,000 tons/yr	.....	Under Constr	1960	.....	Staff	.....
	Kent	*Special Solvents: Redistillation, Acid Washery	30,000 tons/yr	.....	Under Constr	1960	.....	.....	.....
Esso Petroleum	Milford Haven	**Atmospheric Distl**	**100,000 bbls**	.....	**Under Constr**	**Late 1960**	.....	**Foster Wheeler**	**Foster Wheeler**
		Powerformer	**16,500 bbls**						
		Hydrofiner	**16,500 bbls**						
		Electric Coalescer	**31,500 bbls**						
		Other Auxiliaries	.....						
	Fawley	**Petroleum Additives**	.....	.....	**Under Constr**	.....	.....	**Foster Wheeler**	**Foster Wheeler**
Imperial Chemical Industries	Billingham	*Acrylonitrile	.....	.....	Complete	.....	.....	.....	.....
	Wilton	*Polypropylene	10,000 tons/yr	.....	Under Constr	Late 1960	.....	.....	.....
International Synthetic Rubber	Hythe	*Exp. Butadiene-Styrene Rubber	to 90,000,000 lbs/yr	.....	Planning	.....	.....	.....	.....
Mobil Oil Co., Ltd.	**Coryton**	**Crude Unit Exp.**	**5,000 bbls**	.....	**Under Constr**	.....	.....	**Staff**	**Stan**
Monsanto	**Newport**	**Maleic Anhydride**	**15,000,000 lbs/yr**	.....	**Under Constr**	**Late 1960**	**SD**	**SD**	**SD**
	Fawley	*Polyethylene, Pilot Plant Reactor	10,000 tons/yr	$9,000,000	Complete	.....	.....	.....	.....
Northern Gas Board	Darlington	Catalytic Oil Gasification	2 MMcf	.....	Under Constr	.....	.....	Power-Gas	Power-Gas
North Eastern Gas Board	Whitby	Natural Gas Reforming	1.25 MMcf	.....	Engineering	1960	Hercules	Power-Gas	Power-Gas
North Thames Gas Board	**Romford**	**Refinery Tail Gas Reforming**	**36 MMcf**	.....	**Under Constr**	.....	.....	**H & G**	**H & G**
North Western Gas Board	**Manchester**	**Pressure Oil Gasification**	**7.5 MMcf**	.....	**Engineering**	**1960**	**Texaco/ others**	**H & G**	**H & G**
Petrochemicals	**Partington**	**Exp. Ethylene**	**30,000 tons/yr**	.....	**Engineering**	.....	.....	**H W P**	**H W P**
	Partington, Nr. Manchester	**Ethylene Oxide**	**25,000 tons/yr**	.....	.....	.....	.....	.....	.....
Shell Refining	**Shell Haven**	**Hydrodesulfurizer & Gerbotol Modifications**	.....	.....	**Under Constr**	**1960**	.....	**Lummus**	**Lummus**
	Stanlow	**Udex**	.....	.....	.....	.....	**UOP**	.....	.....
South Eastern Gas	**Isle of Grain**	**Hydrogen**	**18 MMcf**	.....	**Under Constr**	**Late 1960**	.....	**Woodall-Duckham**	**Woodall-Duckham**
Southern Gas Board	**Southampton**	**Refinery Tail Gas Reforming**	**16 MMcf**	.....	**Under Constr**	.....	.....	**H & G**	**H & G**
	Reading	**Catalytic Oil Gasification**	**7 MMcf**	.....	**Under Constr**	**1960**	.....	**Power Gas**	**Power Gas**
Union Carbide	Fawley	Ethylene Oxide & Derivatives	.....	.....	Under Constr	.....	.....	.....	.....
UK Atomic Energy Authority	.....	*High Purity Nitrogen	.....	.....	Under Constr	1960	Petrocarbon	Petrocarbon	Petrocarbon
FRANCE									
Antar-Petroles de l'Atlantique	Donges	Crude Topping	62,000 bbls	.....	Planning	.....	.....	.....	.....
Compagnie de Raffinage Shell Berre	**Petit Couronne**	**Distl.**	**80,000 bbls**	.....	**Under Constr**	.....	.....	.....	.....
		Hydrodesulfurizer	**11,000 bbls**	.....	**Under Constr**	**1960**	.....	.....	.....
		Platformer	**14,000 bbls**	.....	**Engineering**	**1960**	.....	**Procon**	**Procon**
	Berre l'Etang	**Furfural**	**3,500 bbls**	.....	**Under Constr**	.....	.....	**Foster Wheeler**	**Foster Wheeler**
Comp Francaise de Raffinage	**Gonfreville l'Orcher**	**Ethylene**	**30,000 tons/yr**	.....	**Under Constr**	**1960**	.....	**Kellogg Int'l.**	.....
Compagnie Francaise de Petrole/ Compagnie Francise de Raffinage/ Pechelbronn	**Strasbourg**	**Refinery**	**70,000 bbls**	.....	**Planning**	.....	.....	.....	.....
Esso Standard	**Port Jerome**	**Additives Plant**	.....	.....	**Under Constr**	**Early 1960**	.....	**Foster Wheeler**	**Foster Wheeler**
Methanolacq	Pardies, pres Lacq	Methanol	100 tons	.....	Under Constr	May 1960	.....	Kuhlmann/STEC	.....
Mobil Oil Francaise	**Gravenchon**	**Lube Exp.**	.....	.....	**Engineering 2nd phase**	.....	.....	.....	.....
					Planning 3rd phase	**1960**	.....	.....	.....
Naphtachimie	**Lavera**	**Exp. Ethylene Oxide**	**60,000,000 lbs/yr**	.....	Under Constr	1960	S D	SFST	SFST
		Exp. Butadiene Recovery	.....	.....	Planning	.....	.....	Foster Wheeler	Foster Wheeler
		*Cat Cracking, Gas Separation	.....	.....	Under Constr	1960	.....	S & W	S & W
		*Ethylene Glycol	.....	.....	Under Constr	1960	.....	Naphthachimie	.....
		*Propylene Oxide	.....	.....	Under Constr	1960	.....	Naphthachimie	.....
Omnium Francais de Petroles		**Refinery**	**75,000 bbls**	.....	**Planning**	.....	.....	.....	.....
Oronite Chemical/ Societe Colifornie-Atlantique	Donges	*p-Xylene	.....	.....	Planning	1960	.....	.....	.....
Pechiney/Dow	Ribecourt	Polystyrene	.....	.....	Planning	1961	.....	.....	.....
Societe des Produits d'Aquitaine	**Chimique**	**Ammonia**	**200 tons**	**$6,000,000**	**Engineering**	**1960**	.....	**Chemico**	**Chemico**
	Lacq	**Acetylene from Nat. Gas**	**75 tons**	.....	**Under Constr**	.....	**BASF**	**BASF/Heurtey**	**Heurtey**
Soc. Francaise des Petroles BP	**Lavera**	**Selective Hydrogenation**	**3,500 bbls**	.....	Under Constr	**April 1960**	.....	.....	**Technip**
Soc. Nationale des Petroles D'Aquitaine	Lacq	*Desulfurization	350 MMcf	.....	Under Constr	1960	.....	Foster Wheeler	Staff
		*Sulfur Recovery	2,000 tons	.....	Under Constr	1960	Parsons	Parsons/Huerty	Staff
		*Natural Gasoline	240 MMcf	.....	Under Constr	1961	.....	Lummus	Staff
		*Ethylene	25,000 tons	.....	Under Constr	1960	.....	Hydrocarbon	Staff
United Carbon	Rouen	*Carbon Black	50,000,000 lbs/yr	$5,000,000	Planning	1961	.....	.....	.....
EAST GERMANY									
DIA Chemie Ausruestung Berlin	Leuna	*Ethylene Aromatics	300,000 lbs	$12,000,000	Engineering	1962	Petrocarbon	Petrocarbon/ H & G	Staff, H & G
Leuna-Werk Walter Ulbricht	.....	*Urea	.....	.....	Planning	.....	.....	.....	.....
		*Ammonium Nitrate	.....	.....	Planning	.....	.....	.....	.....
		*Exp. Nitrogen	to 400,000 tons/yr	.....	Planning	1965	.....	.....	.....

*First appearance in tabulation.

CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Ministry of Coal & Energy	Stralsund	Catalytic Oil Gasification	4.8 MMcf	.....	Under Constr	.....	.....	Power-Gas Didier	Power-Gas Didier
Piersteritz Nitrogen..	.....	*Exp. Nitrogen	to 20,000 tons/yr	.....	Planning	1961	.....	.....	.....
WEST GERMANY									
B.P. Benzin und Petroleum	Dinslaken	Distillation, Cat Reforming, Hydroforming, Copper Chloride	100,000 bbls	.....	Under Constr	1960	.....	Kellogg	.....
Buna Werke Huls	Marl, Kreis Recklinghausen	Exp. Synthetic Rubber	70,000 tons/yr	.....	Planning	Summer 1960	.....	.....	.....
Chemische Fabrik Holten	Lubwigshaven a Rein	Ethylene Oxide	9,000,000 lbs/yr	.....	Under Constr	.....	S D	S D	.....
Chemische Werke Huls	Marl	Polyethylene	6,000 tons/yr	.....	Planning	1960	Ziegler	Staff	Staff
Deutsche Erdoel.....	Heide	Exp. Refinery	50,000 bbls	.....	Planning	1963	.....	.....	.....
Durag-Nerag.....	Misburg, Hannover	Platformer, Sulfur Recovery	4,500 bbls.	.....	Engineering	Sept 1960	UOP	Lurgi	Lurgi
		Delayed Coker	3,000 tons						
		Selective Cracker	21,000 bbls	.....	Under Constr	.....	.....	Lummus	Lummus
		Natural Gasoline							
Deutsche Shell.....	Harburg	Refinery:							
		Crude Distiller							
		Cat Reformer	40,000 bbls	.....	Under Constr	.....	.....	Lummus	.....
		Hydrodesulfurization							
	Godorf	Refinery	30,000 bbls	.....	Under Constr	1960	.....	.....	.....
Erdolchemie.....	Dormagen/ Niederrhein	Propylene Oxide	20,000 tons/yr	.....	Under Constr	1960	Farbenfabriken/ Bayer	Farbenfabriken/ Bayer	Farbenfabriken/ Bayer
		Ethylene	200,000 tons/yr	.....	Under Constr	1960	.....	S & W	S & W
		Ethanol	18,000 tons/yr	.....	Under Constr	1960	Shell	S & W	S & W
		Butadiene	30,000 tons/yr	.....	Under Constr	Late 1960	Esso	Lurgi	Lurgi
		Gasoline Selective Hydrogenation	90,000 tons/yr	.....	Under Constr	1960	BP	BP/Lurgi	Lurgi
		*Di-isobutane	30,000 tons/yr	.....	Engineering	Late 1960	.....	Kellogg International	Kellogg International
Gewerkschaft Erdolraffinerie Emsland	Lingen Holthausen	Crude	32,000 bbls	.....	Under Constr	Early 1960	.....	Lurgi	Lurgi
		Unifiner-Platformer	4,700 bbls	.....	Planning	.....	UOP/ Shell	Lummus	Lummus
		Gas Oil Desulfurizer	5,500 bbls	.....	Planning	.....	UOP/ Shell	Lummus	Lummus
		Kerosine Desulfurization	270 tons	.....	Under Constr	Early 1960	.....	Lurgi	Lurgi
		Gasoline Desulfurization	207 tons	.....	Under Constr	Early 1960	.....	Lurgi	Lurgi
Frisia.....	Emden	Refinery	30,000 bbls	$17,000,000	Engineering	1960	.....	Parsons	Parsons
ali-Chemie.....	Bad Honningen	Hydrogen	.....	.....	.....	1960	Hercules	Power-Gas	Power-Gas
Purfina Mineralolraffinerie	Duisburg	Topping, Platformer Hydrodesulfurizer	20,000 bbls	.....	Complete	.....	UOP, Shell	Lummus/Ubde	Lummus/Ubde
Rheinische Olefinwerke	Wesseling Bez., Kohn Koln	Ethylene	75,000 tons	.....	Engineering	Early 1961	.....	Braun	.....
		Ethylene	.....	.....	Engineering	Jan. 1961	Kellogg	Braun/Lurgi	.....
Ruhrchemie.....	Oberhausen-Holten	Platformer	2,000 bbls	.....	Complete	.....	UOP	Procon	Procon
		Unifiner	2,900 bbls	.....	Complete	.....	UOP	Procon	Procon
		Polyethylene	.....	.....	Under Constr	1960	Staff	Uhde	Staff/Uhde
Westdeutsch Erdolleitungs	Ruhlermoor	Crude Desalter	5,700 bbls	.....	Engineering	1960	Howe-Baker	Uhde	Uhde
GREECE									
Dow Chemical.....	.....	Polystyrene Plastic	.....	$1,000,000	Planning	Early 1961	.....	.....	.....
Greek Government...	Ptolemaeus, Greece	Ammonia	300 tons	.....	Engineering	Mid 1962	Uhde, Casale	Uhde, Casale	Uhde, Casale
		Ammonium Sulfate	525 tons						
		Ammonium Nitrate	325 tons						
IRELAND									
Irish Refining.....	Whitegate	Refinery	32,000 bbls	$33,600,000	Under Constr	1960	.....	.....	Lummus
Esso Petr. (Ireland)									
Caltex (Ireland)									
Shell Mex., B. P.									
ITALY									
Asiende Colori Nazionali Affini	Cengio	Phthalic Anhydride	22,000,000 lbs/yr	.....	Under Constr	Early 1960	Badger Mfg	Badger Mfg	Badger Mfg
Asfalti Bitumi Cementi Derivati, S.A.	Ragusa	Polyethylene	25 tons	.....	Under Constr	.....	.....	BASF	.....
Asienda Nazionale Idrogenazione Combustibil	Ravenna	Styrene Monomer	14,000 tons/yr	.....	Under Constr	.....	Koppers	SBA	SBA
		Butadiene	22,000 tons/yr	.....	Engineering	1960	Houdry	Catalytic	.....
		Ethylene	.....	.....	Under Constr	.....	Koppers	ANIC	.....
Cabot Italiana.....	Revenna	*Carbon Black	85,000 bls	$3,000,000	Under Constr	June 1960	Cabot	Cabot	Techint
Distilleria Italiana....	Milan	Butanol	11,000 tons/yr	.....	Engineering	.....	Hoechst	Ubde	Ubde
Dow Chemical Italiana	.....	*Polystyrene	.....	.....	Planning	.....	.....	.....	.....
Ftalital, S.p.a.....	Italy	Maleic Anhydride	2,200,000 lb/yr	.....	Engineering	.....	S D	S D	.....
Italgas.....	Rome	High-Btu Oil Gas	1.8 MMcf	.....	Under Constr	1960	Semet Solvay	Power-Gas/ SAFII	Power-Gas/ SAFII
Mobil Oil Italiana....	Naples	Cat Reforming	9,000 bbls	.....	Under Constr	.....	.....	CTIP	CTIP
		Cat Hydrodesulfurization	10,000 bbls	.....	Under Constr	.....	.....	CTIP	CTIP
		Lube Exp.	.....	.....	Under Constr	.....	.....	Staff	Staff
		Exp. Polypropylene	.....	.....	Planning	1960	.....	.....	.....
Montecatini Societe Generale per l'Industria Mineraria Chimica	Ferrara	Exp. Formaldehyde	135,000,000 lbs/yr	$300,000	Under Constr	.....	.....	.....	.....
	Castellanza	Petrochemical	700,000 tons/yr	$95,000,000	Under Constr	1962	.....	.....	.....
	Brindisi								
Phillips Petroleum & ANIC	.....	*Carbon Black	25,000,000 lbs/yr	.....	Planning	1962	Phillips	.....	.....
Shell Italiana/Condon	Rho	*Exp. Refinery:	100,000 tons/yr	.....	Planning	Mid 1961	.....	.....	.....
		Fractionation, Aromatic Solvents	.....	.....	.....	.....	.....	.....	.....
Sincat.....	Priolio, Sicily	Ethylene	.....	.....	Under Constr	1960	S & W	S & W	.....
		Treating	.....	.....	Engineering	1960	.....	S & W	.....
Snia Viscosa.....	Varedo, near Milan	Carbon Disulfide	.....	.....	Under Constr	1960	Food	.....	.....
Wtanic Petrolifera....	Livorno	Naphtha Stabilizer and Splitter	11,000 bbls	$720,000	Engineering	1960	.....	Esso	CTIP
Union Carbide	Sicily	Polyethylene	15,000 tons/yr	.....	Under Constr	1960	.....	.....	.....
Societa Edison S.A.	Celene	Ethylene Oxide	26,500,000 lbs/yr	.....	Under Constr	1960	.....	.....	.....
Malta Gas Board.....	Valetta	*Catalytic Oil Gasification	1 MMcf	.....	Under Constr	1960	.....	Power-Gas	Power-Gas
NETHERLANDS									
Dow Chemical International	Rotterdam, Holland	*Styrene-Butadiene Latex	.....	$2,000,000	Under Constr	Spring 1961	.....	.....	.....
Kunstsijde Unie N.V.	.....	Styrene	.....	.....	.....	.....	.....	.....	.....
Esso Nederland.....	Rotterdam	Refinery	95,000 bbls	$50,000,000	Under Constr	Spring 1960	Esso	Esso	Badger N.V
N.V. Mattschappij Tot Exploitatie Van Kooksovengossen	Ijmuiden	*Gas Reforming	4.4 MMcf	.....	Planning	.....	.....	.....	.....
		*CO Conversion	.....	.....	Planning	.....	.....	.....	.....
Staatsmijner in Limburg	Geleen, Holland	*Phthalic Anhydride	.....	.....	Under Constr	1960-1961	S D	SFST	.....
NORWAY									
Standard (N.J.)..	Oslo Fjord	Refinery	40,000 bbls	$30,715,000	Engineering	Late 1960	Esso	Esso	Bechtel

*First appearance in tabulation.

Construction BOXSCORE continued on Page 266

CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
POLAND									
Polimex	Oswiecim	*Polystyrene	35,000 lbs	$1,500,000	Under Constr	1960	Petro-carbon	Petrocarbon	Staff
Polish Government	Plock	*Refinery	40,000 bbls	.....	Planning	1965	.....	.....	.....
PORTUGAL									
Ammoniaco Portugues	Esterreja.	Ammonium Sulfate	220 tons	.....	.....	.....	.....	.....	.....
Sociedade Portuguesa de Petroquimica Sarl	Lisbon	Ammonia	185 tons	.....	Planning	.....	Uhde-Texaco	Uhde-STEC	Uhde-STEC
		Hydrogen	1.5 MMcf	.....	.....	.....	.....	.....	.....
		Fuel Gas	11 MMcf	.....	.....	.....	.....	.....	.....
RUMANIA									
Rumanian Govt.	Teleajen	Lube Oil	.....	.....	Planning	.....	.....	.....	.....
		Natural Gas Treating	.....	.....	Planning	.....	.....	.....	.....
	Borzesti	Petrochemical	.....	.....	Planning	.....	.....	.....	.....
	Onesti	Synthetic Rubber	.....	.....	Planning	.....	.....	.....	.....
SCOTLAND									
British Hydrocarbon Chemicals	Grangemouth	Polyethylene	25,000,000 lbs/yr	.....	Complete	.....	Phillips	S & W	S & W Ltd
		Ethylene	70,000 tons/yr	.....	Under Constr	Mid 1960	.....	S & W Ltd	S & W Ltd
		*Exp. Styrene Monomer	50,000 tons	.....	Under Constr	Dec 1960	Mon-santo	Monsanto	.....
		Gasoline Treater	.....	.....	Under Constr	Early 1960	BP	Lummus	Lummus
Union Carbide	Grangemouth	Polyethylene	30,000,000 lbs/yr	.....	Under Constr	.....	.....	.....	.....
SOUTH AFRICA									
AE & CI	Modderfontein	Synthetic Ammonia	70,000 tons	.....	Under Constr	1960	.....	Staff/ICI/ Power-Gas	Power-Gas
Phillips Petroleum-Industrial Development		Carbon Black	22,000,000 lbs/yr	.....	Under Constr	.....	Staff	Staff	Staff
Standard Vacuum	Durban	Exp. Asphalt Oxidiser	2,100 bbls 600 bbls	$415,000	Under Constr	1960	.....	Staff	.....
SPAIN									
Repesa	Cartegena	Two Stage Crude	35,000 bbls	.....	Engineering	1960	.....	Foster Wheeler	Foster Wheeler
		Fertilizer	.....	.....	Under Constr	.....	.....	Foster Wheeler	.....
SWEDEN									
A. Johnson & Co.	Sweden	Refinery Exp.	.....	.....	Under Constr	.....	.....	Bechtel	Bechtel
Stockholm Gas & Water Works	Stockholm	Cat Oil Gasification	4 MMcf	.....	Under Constr	1960	Power-Gas	.....	Power-Gas
SWITZERLAND									
Power-Gas	Winterthur	Catalytic Oil Gasification	606 Mcf	.....	Under Constr	.....	.....	Power-Gas Didier	Power-Gas Didier
TURKEY									
Badische Anilin and Soda Fabrik	Kutahya	Ammonium Sulfate	60,000 tons/yr						
		Sulfuric, Nitric Acid	50,000 tons/yr	$20,000,000	Under Constr	.....	BASF	BASF	.....
Mobil Overseas, Shell, Caltex BP	Istanbul	Refinery	65,000 bbls	$48,000,000	Under Constr	.....	.....	Foster Wheeler	Foster Wheeler
Turkish Government	Istanbul	Natural Gasoline	.....	.....	Planning	.....	.....	.....	.....
U.S.S.R.									
U.S.S.R. Government	Angarsk, Siberia	*Refinery	.....	.....	Complete	.....	.....	.....	.....
		*Polystyrene	9,000 tons/yr	$1,800,000	.....	.....	.....	Power Gas	.....
	Russia	*Acetylene	.....	.....	Planning	.....	SBA	ERI	ERI
		*Ammonia	.....	.....	Planning	.....	SBA	ERI	ERI
YUGOSLAVIA									
Yugoslav Government	Sisak	Topping and Cat Reforming	15,000 bbls	$5,400,000	Planning	1963	.....	Inst. Pet., Zagreb	Staff
		Ammonia	120/tons	$11,000,000	Planning	1962	Foster Wheeler	.....	.....

Near East

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
ALGERIA									
Cie Francaise des Petroles	Algiers	*Refinery	44,000 bbls	.....	Engineering	1962	.....	.....	.....
EGYPT									
Anglo-Egyptian Oilfields	Suez	Cat Reformer	2,300 bbls	.....	Planning	.....	.....	.....	.....
Egyptian Chem. Ind./.	Aswan	Ammonia	415 tons	.....	Under Constr	1960	Uhde/ BASF	Uhde/BASF	Uhde/BASF
KIMA S.A.E.									
Egyptian Government	Suez	Power	10,000 KW	$2,200,000	Planning	1960	.....	.....	.....
		Atmos. Distl., Vac. Distl. & Lube Oils	20,000 bbls	$7,000,000	Planning	1960	.....	.....	.....
		Cat Reformer	3,000 bbls	$2,700,000	Planning	1962	.....	.....	.....
		Hydrodesulfuriser	2,700 bbls	$720,000	Planning	1962	.....	.....	.....
		Lube Oils	.....	$9,000,000	Planning	1963	.....	.....	.....
	Alexandria	Atmos. & Vac., Distl.	10,000 bbls	$1,400,000	Planning	.....	.....	.....	.....
	Cairo	Atmos. Distl. & Vac., Distl.	10,000 bbls	$1,400,000	Planning	.....	.....	.....	.....
IRAN									
Iran Government	.....	Nitrogen	30,000 tons/yr	$30,000,000	Under Constr	.....	Monte-catini	Foster Wheeler	.....
IRAQ									
Iraq Government	Baghdad	Refinery Exp.	48,000 bbls	$11,000,000	Under Constr	1960	Esso	Foster Wheeler	Foster Wheeler
		Powerformer	5,000 bbls	.....	.....	1960	.....	Foster Wheeler	Foster Wheeler
		Kerosine Treating	5,000 bbls	.....	.....	1960	.....	Foster Wheeler	Foster Wheeler
		Synthesis Gas	121 tons	.....	Under Constr	.....	.....	Foster Wheeler	.....
	Qaiyarah	Refinery Revamp Crude Topping; Vacuum Distl.; Thermal Cracking Asphalt	7,500 bbls	.....	Planning	1960	.....	.....	.....
ISRAEL									
Fertilisers & Chemicals	Haifa Bay	Ammonia Exp. Fertilisers	50 tons	$5,000,000	Under Constr	1960	.....	.....	.....
KUWAIT									
Kuwait Oil	Mina al Ahmadi	*LPG	200 bbls	.....	Complete	.....	.....	Staff	CATC
		*Bulk LPG	8,000 bbls	.....	Engineering	1961	.....	Wimpey-Bechtel International	Wimpey-Bechtel
MOROCCO									
Ente Nazionale Idrocarburi	Mohammedia	Refinery	25,000 bbls	.....	Under Constr	1962	.....	.....	.....
PAKISTAN									
Pakistan Industrial Development	Fruchanj, Pakistan	Ammonia	225 tons	$20,000,000	Engineering	1961	Kobe Steel	Chemico	Chemico
		Urea	375 tons						

*First appearance in tabulation.

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Standard Vacuum Oil, et al	Korangi	*Refinery: Crude Distl Hydrotreater Catalytic Reformer	32,000 bbls	$35,000,000	Engineering	.....	.....	.....	.....
Su ¡Carbon	.....	*Carbon Black	36,000,000 lbs/yr	.....	Planning	.....	.....	.....	.....
SAUDI ARABIA									
Arabian American Oil	**Ras Tanura**	**Alkylation**	**1,210 bbls**	**$6,990,000**	**Under Constr**	**1960**	**Kellogg**	**Kellogg/Staff**	**Staff**
		LPG	**1,500 bbls**	**$1,025,000**	**Engineering**	**1961**	**Kellogg**	**Staff**	**Staff**
		Asphalts	.....	.....	Under Constr	.....	.....	.....	.....
SYRIA									
Syrian Government	**Homs**	**Refinery**	**20,000 bbls**	**$14,000,000**	**Planning**	**1960**	**Technoexport Prague**	**Technoexport Prague**	**Technoexport Prague**
TURKEY									
Caltex, Standard Oil (Calif.), Turkish Govt.	Izmit	*Refinery: Crude Distl Naphtha Unifiner Platformer Distillate Hydrotreater Catalytic Cracker	20,800 bbls	$26,000,000	Engineering	.....	.....	.....	Kellogg
Caltex	Istanbul	*Refinery	.....	.....	Engineering	.....	.....	.....	.....
Mobil International, Royal Dutch Shell BP	Mersin	*Refinery	65,000 bbls	$50,000,000	Under Constr	Late 1961	.....	Foster Wheeler	Foster Wheeler

Far East

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
COMMUNIST CHINA									
	Lanchow	*Refinery	20,000 bbls	.....	Complete	.....	USSR	.....	.....
	Shenyan	*Refinery	.....	.....	Under Constr	.....	.....	.....	.....
HONG KONG									
Hong Kong & China Gas	**Hong Kong**	**Cat Oil Gasification**	**1.5 MMcf**	.....	**Under Constr**	**1960**	.....	**Power Gas**	**Power Gas**
INDIA									
Oil India Private	Noonmati, Assau	*Refinery	750,000 tons/yr	$10,500,000	Under Constr	April 1961	Indian Govt	Rumanian Govt	Rumanian Govt
	Barauni	**Refinery**	**40,000 bbls**	.....	Planning	1962	.....	USSR Govt	USSR Govt.
National Carbon	**Bombay**	**Polyethylene**	.....	.....	**Under Constr**	**Mid 1960**	.....	B & R	B & R
Neyveli Lignite	Neyveli	*Urea	500 tons	$52,500,000	Engineering	Early 1963	.....	Montecatini/ Ansaldo	Montecatini/ Ansaldo
Sahu Chemicals	**Varanasi**	**Ammonium Chloride**	**120 tons**	.....	**Under Constr**	**1960**	**Uhde**	**Uhde**	**Uhde**
		Soda Ash Fertilizer	**120 tons**	.....	**Under Constr**	**1960**	**Pintsch/ Bamag**	**Pintsch/Bamag**	**Pintsch/Bamag**
		Ammonia	**120 tons**	.....	**Under Constr**	**1960**	**John Thompson**	**CECIP**	**John Thompson**
Standard Vacuum	**Bombay**	**Asphalt**	**125,000 tons/yr**	**$2,500,000**	**Under Constr**	**1960**	.....	**Parsons**	**Parsons**
INDONESIA									
Indonesian Government	**Palembang, Sumatra**	**Urea Fertilizer**	**330 tons**	.....	**Under Constr**	.....	.....	**Foster Wheeler**	**Foster Wheeler**
JAPAN									
Asahi-Dow	**Kawasaki**	**Styrene Monomer**	**50 metric tons**	**$4,150,000**	Complete	.....	**Dow**	**Dow**	**Dow**
Asahi Chemical Industries	**Nobeoka**	**NH₃ Synthesis Gas**	**50 metric tons**	**$3,670,000**	**Under Constr**	**1960**	**Texaco/ Chemico**	**Chemico**	**Chemico**
Asia Oil	Yokohama	*Unifiner	3,000 bbls	.....	Engineering	June 1961	UOP	UOP/JGC	JGC
		*Unifiner-Platformer	5,000 bbls	.....	Engineering	June 1961	UOP	UOP/JGC	JGC
		*Merox	4,000 bbls	.....	Engineering	June 1961	UOP	UOP/JGC	JGC
Daikyo Oil	**Yokkaichi**	**Topping & Vacuum**	**30,000 bbls**	.....	Complete	.....	.....	**JGC**	**JGC**
		*Merox	6,000 bbls	.....	Planning	.....	UOP	UOP/JGC	JGC
Furukawa Chemical Industries	**Japan**	**Platforming**	**5,000 bbls**	.....	**Planning**	**Mid 1960**	**UOP**	**UOP/JGC**	.....
Fuji Iron & Steel	Himeji	*Unifining, Udex	700 bbls	.....	Planning	.....	UOP	UOP/JGC	JGC
General Oil	Kawasaki	*Merox	5,700 bbls	.....	Planning	.....	UOP	UOP/JGC	JGC
Idemitsu Kosan	Tokuyama	*Merox	10,000 bbls	.....	Planning	.....	UOP	UOP/JGC	JGC
Japan Synthetic Rubber	**Yokkaichi**	**Butadiene & GR-S Rubber**	**45,000 tons/yr**	**$30,000,000**	Complete	.....	**Houdry Esso Goodyear**	**Blaw-Knox; Catalytic; Chiyoda**	Chiyoda/JGC
Koa Oil	**Iwakuni**	Catalytic Cracker	**5,500 bbls**	.....	Complete	.....	**UOP**	**UOP/JGC**	JGC
		Delayed Coker	**4,500 bbls**	.....	Under Constr	**1960**	UOP	UOP/JGC	JGC
		*Unifining	.....	.....	Planning	.....	UOP	UOP/JGC	JGC
		*Merox	.....	.....	Planning	.....	UOP	UOP/JGC	JGC
		Vacuum Distl.	**8,400 bbls**	.....	Complete	.....	**UOP**	UOP/JGC	JGC
Kokan Chemical Industries	Kawasaki	*Ethylbenzene	328 bbls	.....	Engineering	Oct 1961	UOP	UOP/JGC	JGC
		*Styrene Monomer	13,000 tons/yr	.....	Engineering	Oct 1961	UOP	UOP/JGC	JGC
		*Udex	500 bbls	.....	Under Constr	April 1960	UOP	UOP/JGC	JGC
Kyowa Fermentation Industry Co., Ltd.	.....	**Acetaldehyde**	**45 tons**	.....	**Planning**	.....	**Knapsack-Griesheim**	**Uhde**	**Uhde**
	Ube	**Butanol, Octanol, Acetylene, Ethylene**	.....	**$13,500,000**	**Planning**	.....	.....	**Ilon-Tears**	**Ilon-Tears**
			.....	**$6,500,000**	**Planning**	.....	.....	.....	.....
Maruzen Oil	**Matsuyama**	**Udex**	**1,500 bbls**	**$2,200,000**	Complete	.....	**UOP**	UOP/JGC	**JGC**
		Benzene	**6,600 tons/yr**	.....	Complete	.....	**UOP**	.....	.....
		Toluene	**4,000 tons/yr**	.....	Complete	.....	**UOP**	.....	.....
		Xylene	**4,000 tons/yr**	.....	Complete	.....	**UOP**	.....	.....
		*Unifiner	4,000 bbls	.....	Planning	.....	UOP	UOP/JGC	JGC
		*Udex	1,500 bbls	.....	Planning	.....	UOP	UOP/JGC	JGC
	Shimotsu	*Unifiner-Platformer	6,000 bbls	.....	Planning	.....	UOP	UOP/JGC	JGC
		*Unifiner	4,500 bbls	.....	Planning	.....	UOP	UOP/JGC	JGC
Mitsubishi Oil	Mizushima	*Merox	.....	.....	Planning	.....	UOP	UOP/JGC	JGC
		*Unifiner	.....	.....	Planning	.....	UOP	UOP/JGC	JGC
		*Unifiner-Platformer	.....	.....	Planning	.....	UOP	UOP/JGC	JGC
Mitsubishi Petrochemical	Yokkaichi	*Unifiner-Udex	1,606 bbls	.....	Engineering	April 1961	UOP	UOP/JGC	JGC
		*Ethylene	22,000 tons/yr	.....	Engineering	June 1961	S & W	S & W /JGC	JGC
Mitsui Petrochemical Industries	**Iwakuni City**	**Terephthalic Acid**	.....	.....	Complete	.....	**S D**	**S D**	**Mitsui Shipbuilding**
		*Xylene Isomerization	.....	.....	Under Constr	Spring 1960	Atlantic	SD/JGC	JGC
		Cat Reformer	.....	.....	Complete	.....	.....	.....	.....
Nihon Synthetic Rubber	Yokkaichi	*Petrochemicals	.....	$33,300,000	Complete	.....	.....	.....	.....
		*Exp. Petrochemicals	to 45,000 tons/yr	.....	Under Constr	1963	.....	.....	.....

*First appearance in tabulation.

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CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Nippon Mining	Mizushima	*Unifiner	2,000 bbls	.....	Planning	.....	UOP	UOP/JGC	JGC
		*Unisol	2,500 bbls	.....	Planning	.....	UOP	UOP/JGC	JGC
Nippon Petrochemicals	Kawasaki	*Alkyl Benzene	15,000 tons	$4,000,000	Planning	June 1961	Cal Research	.....	.....
		Unifiner-Udex	1,000 bbls	.....	Planning	.....	UOP	UOP/JGC	UOP/JGC
		*Isopropanol Acetone	6,000 tons/yr 6,000 tons/yr	$2,500,000	Planning	Dec 1960	Distiller	.....	.....
Nippon Petroleum Refining	Yokohama	*Cat Cracker	7,500 bbls	.....	Engineering	June 1961	UOP	UOP/JGC	JGC
Nilto Chemical Industry	.....	Synthesis Gas	125 tons	$6,000,000	Planning	.....	Texaco	Iino-Tears	Iino-Tears
SBA/Sumitomo Chemical	Niihama City	Acetylene-Ethylene	.....	.....	Planning	.....	.....	Staff	Staff
Showa Denko KK	Tokyo	Synthesis Gas	121 short tons	.....	Under Constr	1960	Texaco	Foster Wheeler	Foster Wheeler
Showa Oil	Kawasaki	*Unifiner-Platformer	6,000 bbls	.....	Engineering	Oct 1961	UOP	UOP/JGC	JGC
		*Unifiner	6,000 bbls	.....	Planning	.....	UOP	UOP/JGC	JGC
		*Merox	.....	.....	Planning	.....	UOP	UOP/JGC	JGC
Sumitomo Chemical/ SBA	Niihama City	*Acetylene-Ethylene	.....	.....	Planning	.....	.....	SBA	SBA
Toa Nenryo Kogyo	Shimizu	Exp. Powerformer; Hydrofiner; Kerosine Acid treating; Copper Sweetener; Offsite Facilities	43,500 bbls	$12,500,000	Under Constr	.....	.....	.....	.....
Ube Kosan	.....	Ammonia	100 tons/day	.....	Under Constr	1960	.....	Chemico	Chemico
KOREA									
Korean Government	Chung-ju	Urea	270 tons	$33,500,000	Complete	.....	Inventa-Vulcan	Hydrocarbon, McGraw Vulcan	Hydrocarbon McGraw
	Naju	Urea	95,000 tons/yr	.....	Engineering	1962	Inventa	Lurgi/Uhde	Lurgi/Uhde
Korea Petroleum	Ilsan	Refinery	20,000 bbls	.....	Planning	.....	.....	.....	.....
MALAYA									
Shell of Singapore	Singapore, Malaya Peninsula	*Refinery	.....	$13,300,000	Planning	.....	.....	.....	.....
Shell of Malaya	.....	*Refinery	.....	$20,000,000	Planning	.....	.....	.....	.....
Standard Vacuum	.....	*Refinery, Chemical Fertilizers	.....	.....	Planning	.....	.....	.....	.....
THAILAND									
Thai Defense Ministry	Bangkok	Refinery	5,000 bbls	$20,000,000	.....	.....	.....	Japanese Fuji	Japanese Fuji

Australasia

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
AUSTRALIA									
Australian Oil Refining	Kurnell	Exp. Refinery:	.....	.....	.....	1961	UOP/ Kellogg	Kellogg	.....
		Crude	45,000 bbls	.....	.....	.....	.....	.....	.....
		Cat Cracker	18,000 bbls	.....	.....	.....	.....	.....	.....
		Alkylation	3,400 bbls	.....	.....	.....	.....	.....	.....
Australian Synthetic Rubber	Altona	Synthetic Rubber	.....	$10,000,000	Under Constr	1961	.....	Fluor	Fluor
Bitumen & Oil Refineries	Sydney	Diesel Unifiner	2,500 bbls	.....	Under Constr	.....	.....	UOP	Staff
		Crude	12,000 bbls	.....	Planning	.....	.....	Procon	Procon
CSRC Dow Pty	Altona	Styrene	.....	.....	Under Constr	July 1961	.....	.....	Bechtel/McDonald/Wimpey & Coy
Imperial Chemical Industries of Australia & New Zealand	Clyde	Polyethylene	5,000 tons/yr	$5,040,000	Under Constr	.....	.....	.....	.....
Shell Chemical	Clyde	Resins, Alkylates	.....	$22,000,000	Planning	.....	.....	.....	.....
		*Cat Cracker	.....	$38,000,000	Under Constr	1963	.....	.....	.....
		*Ethylene	.....	$22,400,000	Engineering	1962	.....	.....	.....
Shell Oil	Newport	Oil Blending	.....	.....	.....	.....	.....	.....	.....
Shell Refining (Australia)	Clyde	Platformer	6,700 bbls	.....	Under Constr	.....	UOP	.....	Procon
	Geelong	Hydrodesulfuriser	11,000 bbls	.....	Planning	1960	.....	.....	.....
		Detergent Alkylate	.....	.....	Under Constr	.....	.....	Foster Wheeler	.....
Standard Vacuum	Adelaide	Refinery	30,000 bbls	$30,000,000	Planning	1962	.....	.....	.....
	Altona	Petrochemicals (Ethylene & Butadiene)	20,000 tons/yr	$28,000,000	Engineering	Winter 1961	.....	Fluor	Utah-Australia
Union Carbide	Melbourne	Polyethylene	15,000,000 lbs/yr	.....	Planning	1961	.....	.....	.....
PHILIPPINE ISLANDS									
Filoil Refining	Luzon	Refinery	10,000 bbls	.....	Planning	Late 1960	.....	.....	.....
Shell (Philippines)	Manila	Refinery	.....	.....	Planning	.....	.....	.....	.....
Standard Vacuum	Bataan	Refinery	25,250 bbls	$35,000,000	Under Constr	Late 1960	.....	Foster Wheeler	Foster Wheeler

*First appearance in tabulation.

Atlantic—Atlantic Ref. Co.
Austin—The Austin Co.
Badger N. V.—Badger N. V., Netherlands
Badger Mfg.—Badger Mfg. Co.
B & R—Brown & Root, Inc.
BASF—Badische Anilin & Sod. Fab.
Bechtel—Bechtel Corp.
Blaw-Knox—Blaw-Knox Co.
Braun—C F Braun Co.
Calif. Res.—California Research Corp.
Canadian Badger—Canadian Badger Company Limited
Canadian Bechtel—Canadian Bechtel Limited
Catalytic—Catalytic Construction Co.
Chemical Projects Assoc.
Chemico—Chemical Construction Co.
CTIP—Compagnia Technica Industria Petroli
Dresser—Dresser Engineering Corp.
Ehrhart—Ehrhart & Associates, Inc.
Esso—Esso Research and Engineering Co.
Ferguson—H. K. Ferguson Co.
Fluor—Fluor Corp.
Food—Food Machinery & Chem. Corp.
Foster Wheeler—Foster Wheeler Corp.
Girdler—Girdler Construction Division, Chemetron Corp.
H & G—Humphrey & Glasgow
Hudson—Hudson Engineering Corp.
Hydrocarbon—Hydrocarbon Research, Inc.
HWP—Head Wrightson Process, Ltd.
ICI—Imperial Chemicals, Inc.
JGC—Japan Gasoline Co.
Kellogg—The M. W. Kellogg Co.
Kidde Constr.—Walter Kidde Constructors, Inc.
Kidde Engrs.—Walter Kidde Engineers Southwest, Inc.
Koppers—Koppers Co., Inc.
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Quaker—Quaker Valley Constructors
S&W—Stone & Webster Engineering Corp., Chemical Division
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Stearns-Roger—Stearns-Roger Mfg. Co.
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Where does information come from? Information for BOXSCORE comes to PETROLEUM REFINER through operating and construction company releases, and from hundreds of individual contacts throughout the industry. But in spite of the care used in gathering information, BOXSCORE, we realize, is not 100 percent complete. Occasionally the announcement of a new plant or unit does not, for one reason or another, reach BOXSCORE. That's where you can help!

Our goal is 100 percent. Because our objective is a 100-percent listing of the industry's construction and revamp projects (oil, gas and petrochemical processing plants) we're asking you, the reader, to give us a hand. Simply jot down any omissions you note, or corrections that may be needed, on the form, tear out and mail to BOXSCORE Editor, P. O. Box 2608, Houston 1, Texas. Data submitted will, along with "follow-up" information from the operating company and/or engineering-contractor, be published in the July BOXSCORE.

Oil, Gas and Petrochemical Processing Projects

	1.	2.
Company		
Project Site		
Project		
Daily Capacity		
Estimated Cost		
Planning, Engineering Under Construction or Completed		
Probable Completion		
Licensor		
Engineering		
Contractor		

Information submitted by: _____

Company and Title _____

What's Happening...

IPAA Predicts Increase in Demand

Second quarter estimated at 9.4 million bpd, up 4 percent over same 1959 period

A 400,000-bpd increase in total petroleum demand during the second quarter of this year over the same period in 1959 has been forecast by the Independent Petroleum Association of America.

In its monthly Supply and Demand Outlook the association stated total demand during the second quarter is expected to be 9.4 million bpd, four percent higher than in the same period last year. Total demand during the peak winter months of December through February averaged 10.8 million bpd, a decline of more than 350,000 bpd from the like period last winter.

Why the Decline? This decline was the result primarily, the association said, of unseasonably warm weather during December and January. However, extremely cold temperatures during the first half of March are expected to at least partially offset the effect of the earlier warm weather.

The IPAA stated that if gasoline demand begins its normal seasonal increase in March, total demand for the month could remain close to the February level of about 10.5 million bpd.

Storms a Factor. The storms which have swept the Midwest, South and East during the first half of March have gone a long way in reducing unseasonably high inventories which were evident at the end of February when they totaled 772 million barrels, 20 million barrels higher than at the same date last year and 47 million barrels higher than was forecast by the IPAA Supply and Demand Committee last October.

The association pointed out that if March demand does approximate 10.5 million bpd, a reduction in total inventories of 20 to 25 million barrels could take place "in a month when total inventories normally remain level or begin seasonal increases."

Supply Needed. In view of the expected seasonal decline in demand and inventory situation at the end of March, the Outlook stated that total supply needed during the second quarter is expected to be about 9.46 million bpd. With imports estimated at 1.6 million and natural gas liquids production expected to average about 875,000 bpd, the market for domestic crude oil should average about 7 million bpd, the IPAA said. This would compare with an estimated production of 7.1 million bpd during March and 7.2 million bpd during the same period last year.

Consumption Down. Lower demand in 1960 has reflected primarily the relatively light consumption of distillate fuel oil, kersosine, and residual fuel oil, due to milder than normal winter weather. Daily average demand for distillate fuel in January and February 1960 was 8.3 percent smaller than in those months of 1959. Kerosine demand was down 15.5 percent. Residual fuel oil demand was off 9 percent.

Helping to depress residual consumption was the fact that, because of relatively mild weather, many industrial consumers were able to go on using natural gas instead of having to switch temporarily to oil during the winter to release more gas for residential and commercial use. Ordinarily, residual must substitute importantly for natural gas at industrial plants in winter.

Gasoline Holds Own. Gasoline demand has held up relatively better than demand for other products, but even it has been disappointing. Daily average demand for gasoline in January-February 1960 was 1 percent less than in those months a year ago.

While demand for petroleum has been disappointing this year, the industry has been taking notice of lagging sales, particularly during the past month, and has been trying to adjust supply into better balance with the demand. The results have been fairly satisfactory, in that stocks of crude oil and gasoline remain reasonable and refinery runs of crude oil have been curtailed.

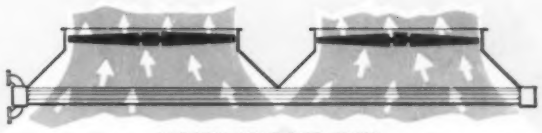
Distillates Down. However, stocks of distillate fuel oil became seriously excessive as sales lagged during relatively mild weather of December and January. And the surpluses of distillate have remained in February and March. Distillate stocks of 105 million barrels at the end of February were 25 percent greater than those of 84 million a year earlier.

Under the burden of the surplus, the markets for distillate have been weak, and wholesale prices were further reduced in early March.

To some extent it will be practical in coming months for refiners to convert distillate fuel oil into gasoline and thus market it in that form.

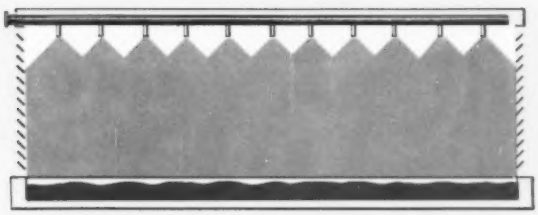
Should Process Plant Cooling Systems Use..

AIR ——————



HUDSON SOLO-AIRE UNITS

WATER ——————



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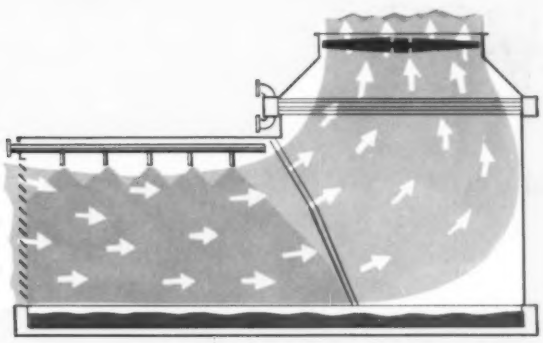
or a combination of AIR AND WATER ——



HUDSON COMBIN-AIRE UNITS

The answer is found only through comparisons of economics of air, water or a combination of the two for cooling each process stream, and incorporating the results in one integrated cooling system. Factors to be considered include desired effluent temperature of each process stream; summer and winter ambient dry and wet bulb temperatures; availability and quality of water; possibility of public water pollution; space available; and first cost, maintenance cost, and operating cost of equipment.

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Happenings . . .

Refining's Future, 1960-70 Discussed by Planning Exec

With the number of automobiles on the road expected to increase from the current 60 million to 85 million in 1970, gasoline refiners must plan not only for a 30 percent increase in U.S. gasoline consumption over the next decade but also for cars having octane requirements of 103.5 and over by 1966.

That prediction, encouraging from a business standpont but presenting new technological challenges to the industry, was presented at the Delaware Valley Regional Meeting of ACS by John R. Sabina, planning manager of E. I. du-Pont de Nemours & Co.'s Petroleum Chemicals Division.

Based on a study of trends in automobile engine design and resultant fuel demands, he said, flexibly designed catalytic reformers will be the "backbone of tomorrow's refinery for production of premium grade gasoline." In addition, alkylation, hydrocracking and isomerization also will be used in increasing degrees, along with new types of antiknock additives, to attain the required gasoline quality level.

Pointing to an increase in octane rating of average premium grade gasolines from 92.4 in 1954 to 99.2 in 1959, which he said was sufficient to satisfy the antiknock requirements of all but 10 percent of the newest model cars, Sabina credited much of the improvement in gasoline quality to catalytic processing. Catalytic cracking, he noted, has increased almost fivefold between 1945 and 1960, while catalytic reforming capacity has increased almost tenfold in the last seven years.

"Tremendous demands have been made of the refining industry in the last few years," he said, "while giant strides have been made by the petroleum industry in supplying the higher quality automotive fuels which have allowed engine designers to produce more economical and efficient automotive power plants." These technological advances, he pointed out, have resulted in motorists having received higher quality products at an increased cost of only a cent per gallon, less taxes, over the last nine years. At the same time, however, taxes levied by federal and state governments have increased 2.1 cents per gallon.

Challenges to be met by the refining industry, Sabina told the ACS group, include both higher production and higher quality fuels to satisfy projected engine designs.

One factor tempering more optimistic predictions of gasoline consumption in the next decade, he pointed out, is growing popularity of small imported and compact American cars. Registration of small cars is expected to reach 19 million by 1970, or about 22 percent of all cars on the road in that year, and then level off at about that point. Higher fuel economy of the small cars, he predicted, will reduce annual gasoline consumption by four billion gallons in 1970. Nevertheless, domestic highway consumption

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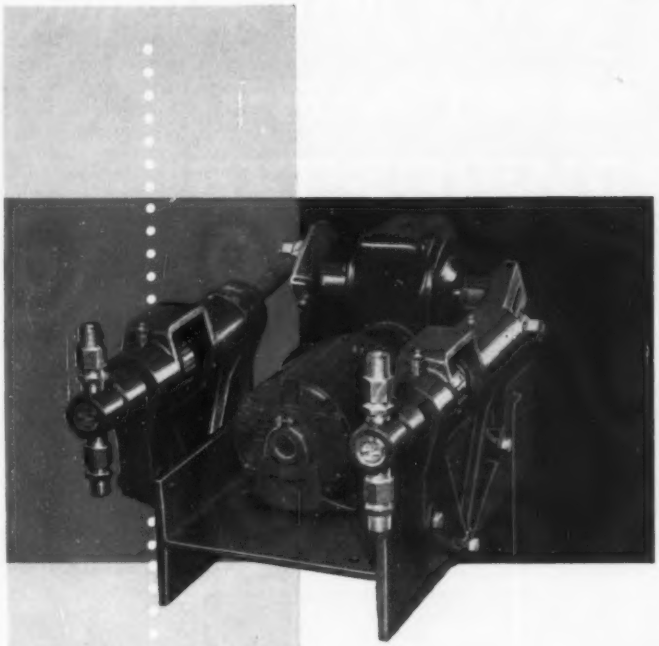

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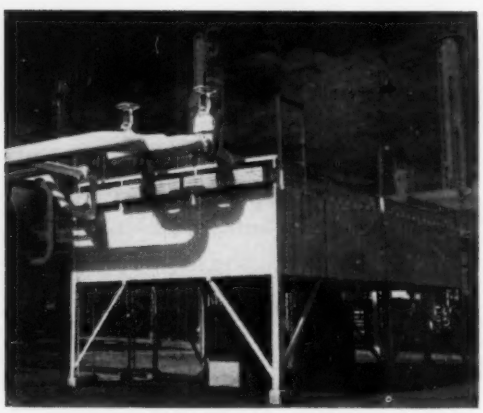
of gasoline over the next decade should increase about 2.7 percent per year. However, if the current ratio of small to large cars were to remain the same, a 3.5 percent gasoline growth rate is predicted over the next decade.

"The increasing number of low horsepower foreign imports and the relatively large volume sales of the new American compact cars should mean that average horsepower figures will decrease over the next few years," Sabina observed, "but predictions of the horsepower trend of the future, are difficult to make until public response to introduction of the compact cars is more firmly established."

Higher compression ratios—desirable from the engine manufacturer's standpoint because they increase engine efficiency and power output per unit of engine weight—have resulted in demand for higher octane quality fuels. Octane rating of average premium grade gasoline, for example, has risen from 92.4 in 1954 to 99.2 in 1959, sufficient to meet fuel demands of 96 percent of all cars on the road. Octane requirements are expected to rise steadily through the next six years, with 1966 estimates varying from 103.5 to satisfy 95 percent of new cars to 98 to accommodate at least 50 percent of that year's new models.

Hi Fi SET?



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Discusses Chem Industry Problems for New Decade

The chemical industry must solve six crucial problems in the coming decade, stated Dr. R. L. Bateman, director of market development, Union Carbide Chemicals Co., at the recent ASC's Delaware Valley Regional Meeting. Dr. Bateman cited the post-war emergence of synthetic organic chemicals as the "dynamic segment of the chemical industry" and pointed out that the industry's paramount challenge today is to maintain the growth rate established during the past fourteen years.

Attainment of this over-all goal can be achieved only if the industry successfully meets specific challenges in six key areas, Dr. Bateman said. Summarizing these in general, he defined them as raw materials, research and development, capacity and demand, foreign competition, technical manpower requirements, and market development. "Each of these areas presents a major challenge that must be solved satisfactorily if the synthetic organic industry is to continue its growth at a rate greater than the overall economy."

"A continued supply of raw materials at a fair cost is essential," Dr. Bateman said. "There is no question but that required quantities of raw materials can be made available from some source, but the value placed on such hydrocarbons by producers can have a significant effect on the costs of finished chemicals, which in turn will determine the expansion of chemical markets."

In addition, the tempo of both basic and applied research must be accelerated in the 1960s if the industry is to develop new products and processes to thwart the always prevalent obsolescence. "The research departments of the industry must keep in mind and practice three basic rules," he pointed out. "They must create new products to satisfy human needs, they must create synthetic products which will out-perform natural products, and they must create new processes to make the first two possible." In turn, an adequate and profitable ratio between capacity and demand can only be achieved by timing expansion of facilities so that markets will consume the organic chemicals produced.

Anticipating that competition from foreign sources will continue to increase in the 1960s, the industry's problem is two-fold. Continued profitable sales to foreign countries can be maintained by producing new materials for export, and by reducing costs utilizing our own technological advances.

The fifth challenge cited by Dr. Bateman, the need for more and better technical manpower, cannot be minimized. He emphasized that support of educational programs by industry must be assumed as a basic responsibility.

In conclusion, Dr. Bateman summarized the final problem as "the need to penetrate other industries which now use few or no synthetic organic chemicals. The chemical industry must work to

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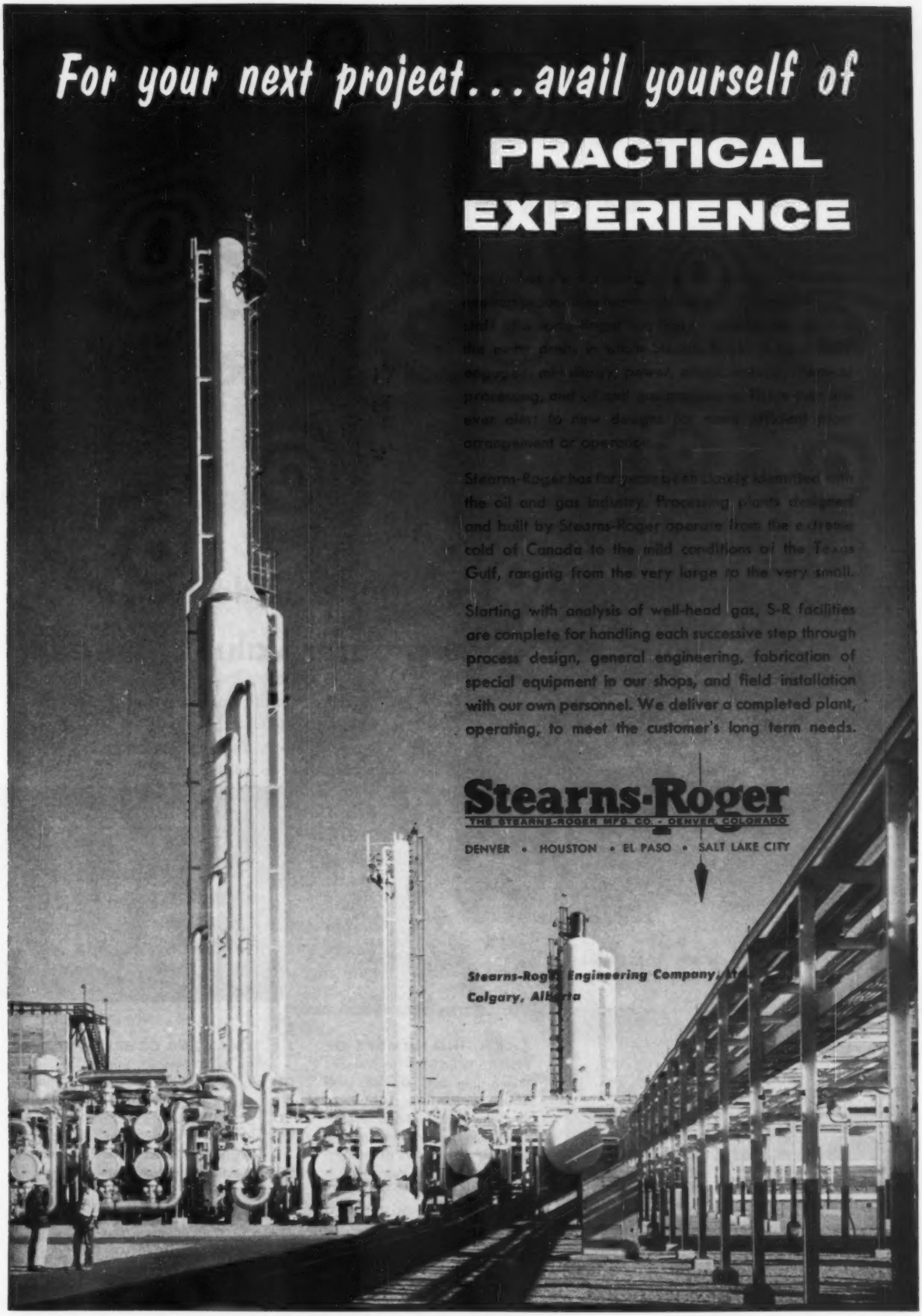

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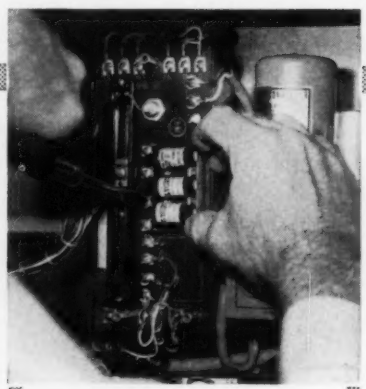

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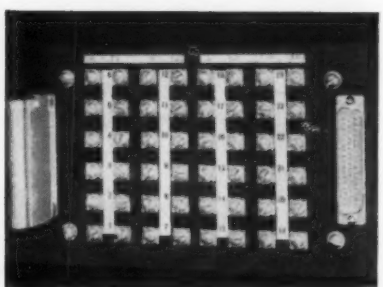

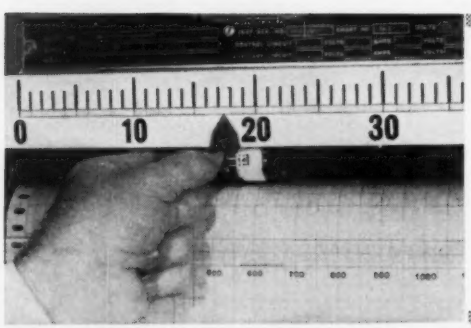

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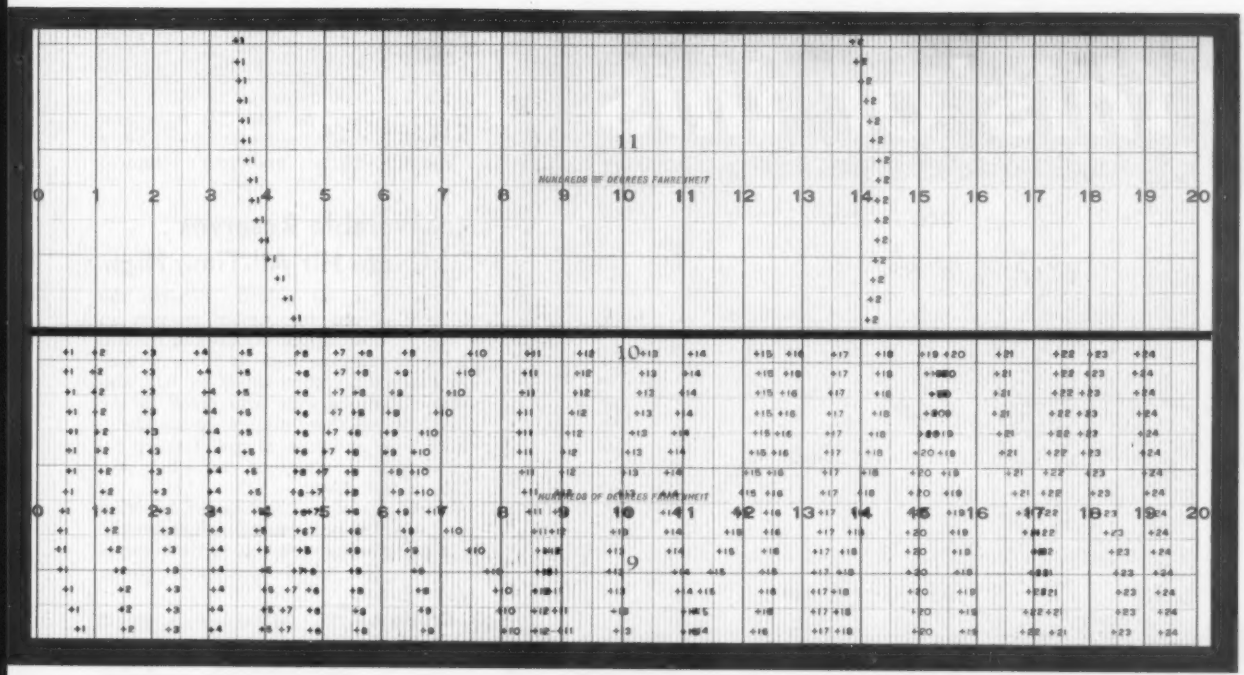

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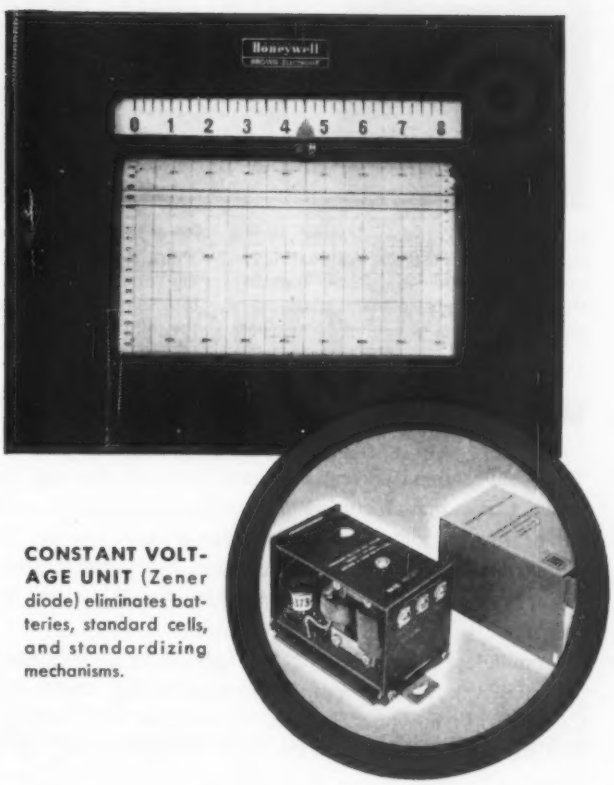

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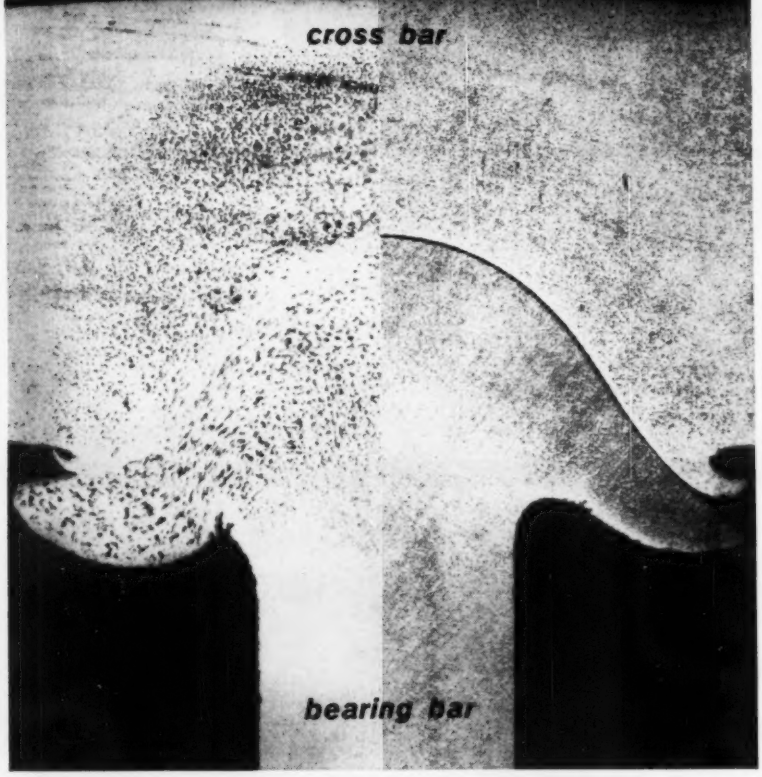

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Happenings . . .

supply a greater share of the raw materials for those industries to which it is already selling," he said. "It must also broaden its base by penetrating still other industries with new and better chemical products."

Recoverable Reserves Of Crude Hit All-Time High

The U. S. oil industry brought the nation's proved recoverable reserves of crude oil, natural gas liquids and natural gas to an all-time high in 1959, according to annual reports issued by API and AGA. Increases were also noted in the production of these supplies of liquid hydrocarbons and natural gas, a sharp reversal from the previous year when production was down.

Highlights of the 1959 report, covering the calendar year ended December 31 and representing estimates of the reserves committees of the two trade associations, are as follows:

Crude oil. 31.7 billion barrels, up 1.2 billion over 1958.

Natural gas liquids. 6.5 billion barrels, an increase of 318 million over the previous year.

Total liquid hydrocarbons. (Crude oil and natural gas liquids): 38.2 billion barrels, up 1.5 billion over 1958.

Natural gas. 262.6 trillion cubic feet, an increase of 8.5 trillion over 1958.

The reserves committees estimated production of crude oil at 2.5 billion barrels, up 110 million over 1958; natural gas liquids at 385 million barrels, an increase of 44 million over 1958; and total liquid hydrocarbons, 2.87 billion barrels, up 154 million over the previous year. Natural gas production rose 956 billion feet to 12.4 trillion.

As in other years, a large percentage of the increase in total liquid hydrocarbon reserves came from extensions and revisions of previous estimates covering pools and fields discovered prior to 1959. This results from the fact that no field of any consequence is ever fully developed during the year in which it is first discovered.

For this reason, new discoveries during a given year are as a rule very small in comparison with the reserves later developed in the same fields through further drilling effort and increased knowledge of reservoir characteristics.

Fire Protection Authorities Will Meet in Montreal

Fire protection authorities from all over the world will meet in Montreal in May to discuss how to make people and property safer from fire. Topics ranging from industrial plant protection to fire safety education will be among those covered at the week-long annual meeting of the National Fire Protection Association.

The meeting, opening May 16 at the Queen Elizabeth Hotel, will be the first

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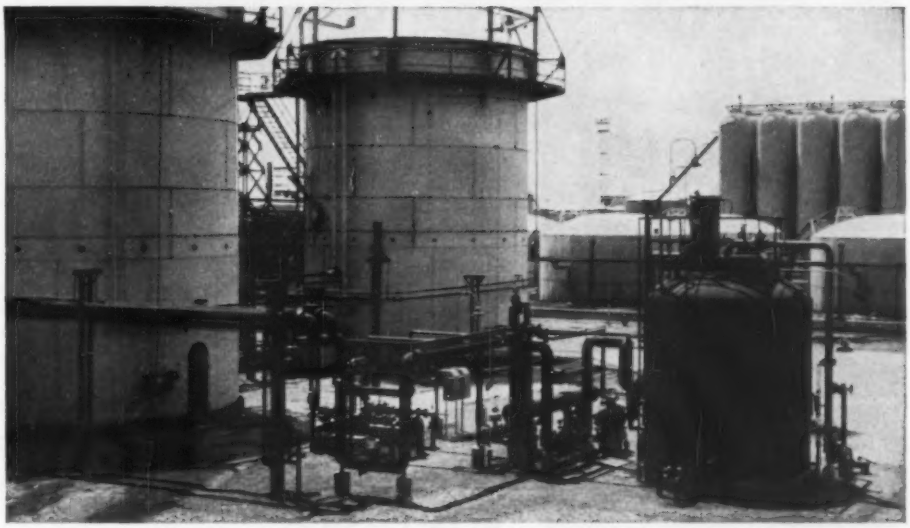

Compare the small, compact Petreco Electrofining Precipitator in the foreground with the large-diameter, twice-as-high open agitators.

Cities Service reduces oil-treating caustic from 15000 to 3400 lbs./month with ELECTROFINING precipitator*

Since the Cities Service Oil Company refinery in East Chicago, Indiana, replaced its two large air-blown agitators with an ELECTROFINING Precipitator, the caustic needed to treat burning oil has been reduced from 15000 pounds per month to 3400 pounds per month. This is possible because the intense caustic contact with the ELECTROFINING Precipitation Equipment enables *less caustic to do more work.*

OTHER IMPORTANT ELECTROFINING PRECIPITATION BENEFITS

■ ***ELECTROFINING Precipitation Equipment Simplifies Waste Disposal.*** When agitators were used, 15000 pounds of oil contaminated caustic had to be disposed of every month. The ELECTROFINING unit has reduced the amount to be disposed of to 3400 pounds per month. Since the ELECTROFINING unit is vapor-tight it permits no escape of oil vapors to the atmosphere as the agitators did.

■ ***Requires Less Construction Material; Less Space.*** Note the physical difference. The amount of sheet steel and pipe required for the construction of the agitators was many fold that used in the custom-built, virtually pre-fabricated ELECTROFINING Precipitator. The real estate occupied by the ELECTROFINING unit is only one-third the amount of space required by the agitators.

■ ***Replaces Manual with Automatic Operation.*** Agitator treatment is controlled by the judgment and experience of human operators. ELECTROFINING units are automatically controlled at all times to provide optimum treating efficiency as established by laboratory pilot-plant operation.

■ ***Reduces Heating Requirement.*** After agitation the oil had to be heated to 120°F. to remove water haze. The ELECTROFINING unit treats the oil at 85°F. and no after treating heat is required so that total fuel requirements are reduced.

Find out now how ELECTROFINING in your operation can save dollars and make sense. Write or call . . .

*ELECTROFINING *is a registered trademark of Petrolite Corporation.*

DT-60-4

PETROLITE CORPORATION

PETRECO DIVISION
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1390 East Burnett Street (P.O. Box 7216), Long Beach 7, California

CANADA: Petreco, 4528 Stanley Drive, Calgary, Alberta
COLOMBIA: South American Petrolite Corporation, Bogota
ENGLAND: Petrolite Limited, 20 Savile Row, London W.1
GERMANY: Petrolite Anlagenbau und Vertriebsgesellschaft m.b.H., Frankfurt a. M.
VENEZUELA: South American Petrolite Corporation, Hotel Avila, Caracas

REPRESENTATIVES

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BRAZIL: WERCO, Ltda., Rio de Janeiro
ITALY: NYMCO, S.p.A., 9 Lungotevere A. da Brescia, Rome
JAPAN: Chiyoda Chemical Engineering and Construction Company, Ltd., Tokyo
KUWAIT: F. N. Dahdah, Box 1713, Al Kuwait
MEXICO: R. E. Power, Sierra de Mijes No. 125, Mexico, D. F.
NETHERLANDS: F. E. C. Jenkins, Hoefbladlaan 134, The Hague
TRINIDAD: Neal and Massy, Ltd., P. O. Box 544, Port of Spain

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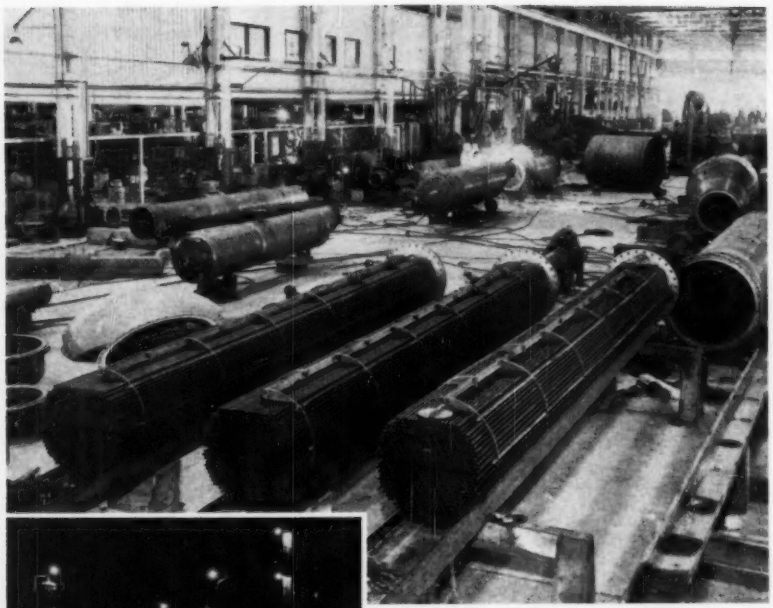

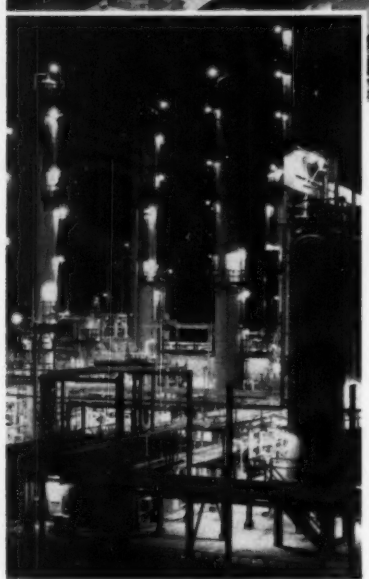

FLINT can fabricate any type of petroleum and chemical PROCESSING EQUIPMENT

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More than forty years of manufacturing experience, the largest and the most modern plate shop facilities in the Southwest enable Flint to design and fabricate, to code, and meet delivery requirements competitively.

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Write for booklet describing Flint's new steel fabricating facilities.

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STEEL PLATE FABRICATORS ASSOCIATION

SPECIALISTS IN STEEL FOR INDUSTRY

Happenings . . .

held in Montreal by NFPA, which has substantial Canadian representation among its 17,000 members. It is expected to be attended by about 2,000 persons. Speakers on the program will include fire experts from Great Britain, Germany, Japan, the United States and Canada.

Proposed changes and additions to the National Fire Codes, prepared and published annually by the association, are to be debated and acted upon. Among the many fire subjects to be discussed during the five-day meeting will be chemical processing safety, developments in extinguishing agents, flammable liquid hazards, storage of gases, aircraft fueling procedures, and cutting and welding hazards.

Plant Engineering Meet Will Cover Maintenance

Current developments in maintenance of machinery and equipment will be the subject of a national engineering conference in St. Louis, April 25-26. The Maintenance and Plant Engineering Conference of ASME will feature discussions of such topics as: "Are You Getting the Plant You Want—And Paid For?," "Industrial Lighting," "Planning and Scheduling Machinery and Equipment Maintenance" and a forum on specific problems suggested by conference attendees.

Other papers presented will cover Developments in Maintenance Welding—Chemical Plants; Maintenance Men: Important Today—A Necessity Tomorrow; and Maintenance of Power Transmission and Conveying Equipment.

Instrumentation Automation Meeting Slated for May

Subjects ranging from air pollution and the instruments used to determine its nature and extent to the proper specification and use of control valves in industrial processes, will be covered at the summer Instrument-Automation Conference & Exhibit being held by ISA. The meeting will be in San Francisco's Civic Auditorium and Brooks Hall, May 9-12. This will be the first Conference & Exhibit the society has ever held in San Francisco.

The event is expected to attract more than 5,000 persons from the United States and Canada. Approximately 25 technical sessions will be held during the four days and 60 papers will be delivered. All sessions will be held in the Civic Auditorium. The exhibit, to be held in Brooks Hall adjacent to the Auditorium, will be open May 10-12. It will feature the display and demonstration of the latest in instruments, controls, systems and components of 200 leading manufacturers. Being held simultaneously with, but separately from the conference and exhibit, will be ISA's 3rd National Power Instrumenta-

For more data on advertised products, use Readers' Service Cards, last page

SPENT SULPHURIC ACID
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SPENT H_2SO_4 that is!

There probably isn't a bigger headache in industry than spent sulphuric acid.

Yet it's a waste you can't afford to waste . . . and rarely afford to salvage yourself.

We suggest you turn it over to pro's with the world's largest facilities for regeneration of spent acid and delivery of water-white H_2SO_4.

Consolidated Chemical Industries handles any processable spent acid wastes from lube oil, naphtha, DDT, benzene, alkylation, alcohol, detergent and other processes . . . and you'll be surprised what we can handle!

What's more . . . you will get back virgin acid tailor-made to your process strength, accurate to 1/10th of 1%.

Give us a call if you have problems with Spent Sulphuric Acid.

Spent Acid regeneration plants at Houston and Baytown, Tex., Baton Rouge, La., Hammond, Ind., and Dominguez, Cal. Sulphuric Acid is also shipped from other plants at Fort Worth and Corpus Christi, Tex., LeMoyne, Ala., Vernon and Richmond, Cal., and Tacoma, Wash.

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380 Madison Avenue, New York 17, New York
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CONSOLIDATED CHEMICAL INDUSTRIES DIVISION, 6910 Fannin St., Houston 25, Texas

75 YEARS OF SERVICE TO INDUSTRY AND AGRICULTURE 1885 1960

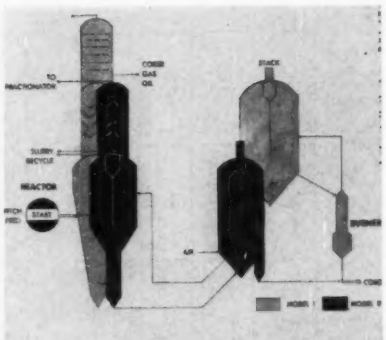
tion Symposium at San Francisco State College, May 9-11. This is being conducted under the Power Industry Division.

ASTM to Study Protection Of Computers from Fire

A new technical committee on electronic computer systems has been established by the National Fire Protection Association.

Set up at the request of the computer industry, the committee will study problems of providing protection from fire for equipment installations, components and associated records. The Pentagon fire of last July, with losses estimated to total at least $6.7 million, is an indicator of the high property values involved with computer equipment, aside from the possibly even greater value of stored data and records.

The committee will function under the same procedures used by more than 100 NFPA technical committees whose standards and recommendations are used as the basis of good practice by industry and as regulatory measures. Chairman of the NFPA Committee on Electronic Computer Systems is John J. Ahern, director of security, General Motors Corp., Detroit.



MODEL II FLUID COKING

Esso R & E Introduces New Model of Refining Process

A new model of a petroleum refining process which makes possible the conversion of low-value oil materials into gasoline and home-heating oil has been developed by Esso Research and Engineering Co. The new version of the process, known as "Model II Fluid Coking," can be installed and operated at up to one-third less cost than the original model which was introduced in 1953.

The new design is a more compact unit having a lower silhouette and requiring a smaller plot area. For example, the coke burner, the largest diameter vessel, which supplies heat to operate the process, has been made 30 percent lower in height. Utility costs could be cut up to 35 percent by application of a unique waste-gas turbine to drive the burner air blower and by other operating economies, including elimination of externally provided high pressure steam.

January Sees Decrease in Crude, Products Imports

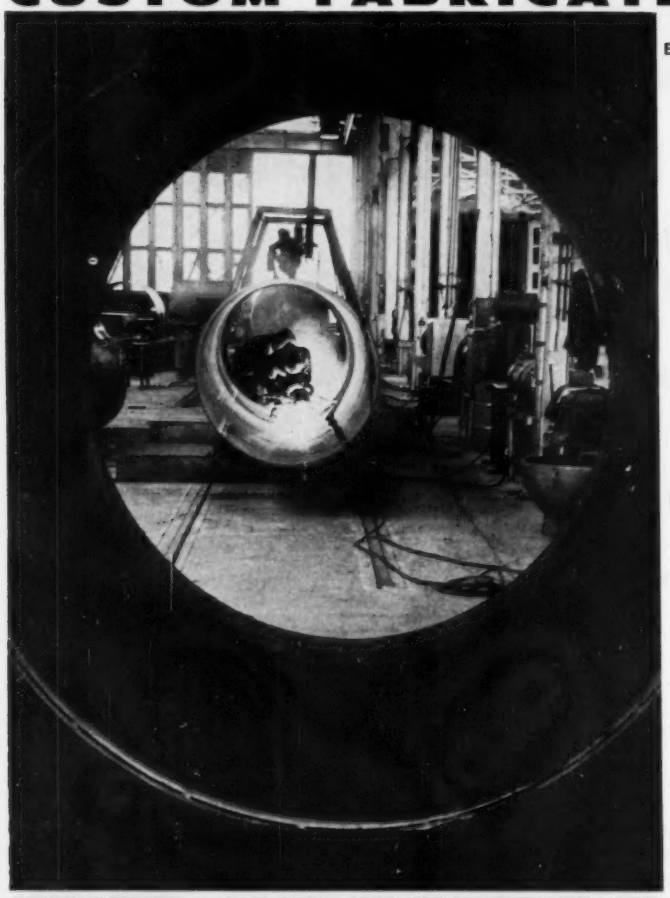
U.S. imports of crude oil and products into the United States dropped in January to 1.79 million bpd from 1.98 million in December and 2.1 million in January 1959, according to the Bureau of Census. Crude oil imports averaged 818,000 bpd in January, compared with 1.1 million in December and 955,000 in January 1959. Residual imports averaged 852,000 bpd in January, compared with 718,000 in December and 873,000 in January 1959.

April Demand Is Forecast By the Bureau of Mines

The amount of crude oil consumed in the United States or exported this month has been estimated at 6.55 million bpd by the Bureau of Mines. This compares with 6.89 million bpd predicted for March 1960. The bureau's forecast includes estimates of total gasoline demand of 4.29 million bpd in April, a gasoline yield of 45.4 percent and crude runs of 7.42 million bpd.

Data for January include total crude runs of 8.27 million bpd, including 936,000 bpd of foreign oil. Indicated crude

CUSTOM FABRICATION



COMPLETE ENGINEERING FACILITIES
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PROCESS TOWERS FOR THE REFINERY & CHEMICAL INDUSTRY
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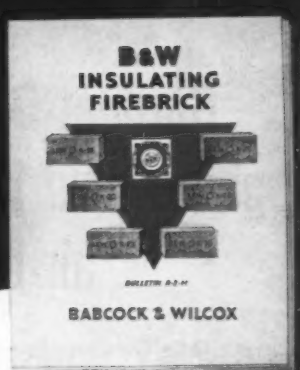
TRINITY STEEL COMPANY, INC

TRINITY STEEL

4001 IRVING BLVD.—DALLAS, TEX.—FL 7-3961. LATIN AMERICAN DIVISION: TANQUES DE ACERO TRINITY S. A., CALLE PONIENTE 150, #734, MEXICO 16, D. F. PLANT AND SALES OFFICE. PLANTS IN: DALLAS, TEXAS; FRANCESVILLE, INDIANA; MEXICO CITY, D. F.

Why B&W IFB for Oil Heater Linings ?

- Lightest weight
- Simplified construction
- High hot load strength
- Lower conductivity
- Lower heat storage
- Better process control



The light weight of B&W Insulating Firebrick provides savings in capital investment in several different ways. The light weight of B&W IFB permits thinner wall constructions of equivalent insulating value. These thinner, lighter walls mean real savings in structural steel and concrete. Construction is further simplified because B&W IFB's high hot load strength makes possible higher unsupported walls without deformation at furnace operating temperatures. In addition B&W IFB can be cut and shaped with ordinary wood working tools, simplifying field installation.

The light weight of B&W Insulating Firebrick also provides the greatest insulation. Thus, they save more fuel.

Light weight also means lower heat storage. B&W IFB protect you against burn-out of expensive alloy tubing in the event of forced shutdown. B&W IFB respond faster to changes in firing rate, too, assuring you of more positive process control.

**Write for Bulletin R-2-H giving more data on B&W Insulating Firebrick.*

B&W

THE BABCOCK & WILCOX COMPANY

REFRACTORIES DIVISION

B&W Firebrick, Insulating Firebrick, and Refractory Castables, Plastics, Ramming Mixes, Mortars, and Ceramic Fiber.

WORK HORSE... RACE HORSE

Gardner-Denver piston and rotary air hoists

Only Gardner-Denver offers lightweight overhead air hoists for *both* the "work horse" and "race horse" jobs. Axial-piston hoists provide rugged, dependable operation with the control demanded for precise spotting. That's why hundreds of industrial plants rely on this Gardner-Denver hoist. New rotary air hoists are designed for use where the combination of speed and ruggedness is of primary importance—up to 90 fpm in 500-lb. capacity.

Popular models available from 150-4000 lb. Sparkproof construction and pendent control available.

PISTON HOISTS				ROTARY HOISTS			
MODEL	CAPACITY	SPEED	WEIGHT	MODEL	CAPACITY	SPEED	WEIGHT
86-1V10	1000	19	28	86R-5	500	90	27
86-2V20	2000	19	78	86R-10	1000	40	27
86-2V40	4000	10	100	86R-20	2000	20	30

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

GARDNER-DENVER

Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Ave., Toronto 16, Ontario

Happenings . . .

runs to stills for February were 8.09 million bpd, including 986,000 bpd of foreign oil. Indicated demand for domestic crude oil in February was 7.15 million bpd with a production figure of 7.28 million bpd.

Indiana-Standard Walkout Ends Without New Contract

An eight-month OCAW walkout by employes at Standard Oil Co. (Indiana) 75,000-bpd Sugar Creek, Mo., refinery ended early in March after union members voted 199 to 144 to return to work "unconditionally", and without signing a work agreement. Contract-settlement negotiations will continue. Federal conciliator Arnold Griffith says that he will call another session as soon as either party requests it. Until an agreement on a new contract is reached, union members will be working under terms of Standard's latest contract proposals, "with certain exceptions." Work rules have been the key issue in the strike, which started in July 1959. Wages have not been a controversy. The company claims that it has been operating the refinery at 83-percent of capacity, using supervisory personnel and strikers who returned early.

Residual Imports, Stocks Reported for February

Imports of residual fuel into Districts 1-4 totaled 19.4 million barrels in February, according to the Oil Import Administration. Non-bonded stocks of residual on the Gulf and East coasts totaled 23.3 million barrels at the end of February. February importers bought 25 percent of the total residual allocation for the January-June allocation period, leaving 45.9 percent available for import during the period's remainder.

Bonded residual stocks on the Gulf and East coasts at the end of February totaled 5.2 million barrels. Stocks reported were held at refineries, bulk plants and terminals. Imports for the first two months of this year were 41.8 million barrels, out of an allocation for the six-months period of 77.3 million.

Oil, Auto Industries Add To Air Pollution Fight

Cooperation from the petroleum and automobile industries in combatting air pollution is "much more . . . than we ever had before," said Dr. Leroy Burney, U.S. surgeon general at a recent meeting of Congress. He said that the Public Health Service is getting this cooperation through what the industries are doing themselves in research, and through development of government-industry research projects.

Industry is also making sure that "everyone is more aware of the results of research, from whatever source." Last year, Dr. Burney stated that he was dissatisfied with oil industry-auto efforts,

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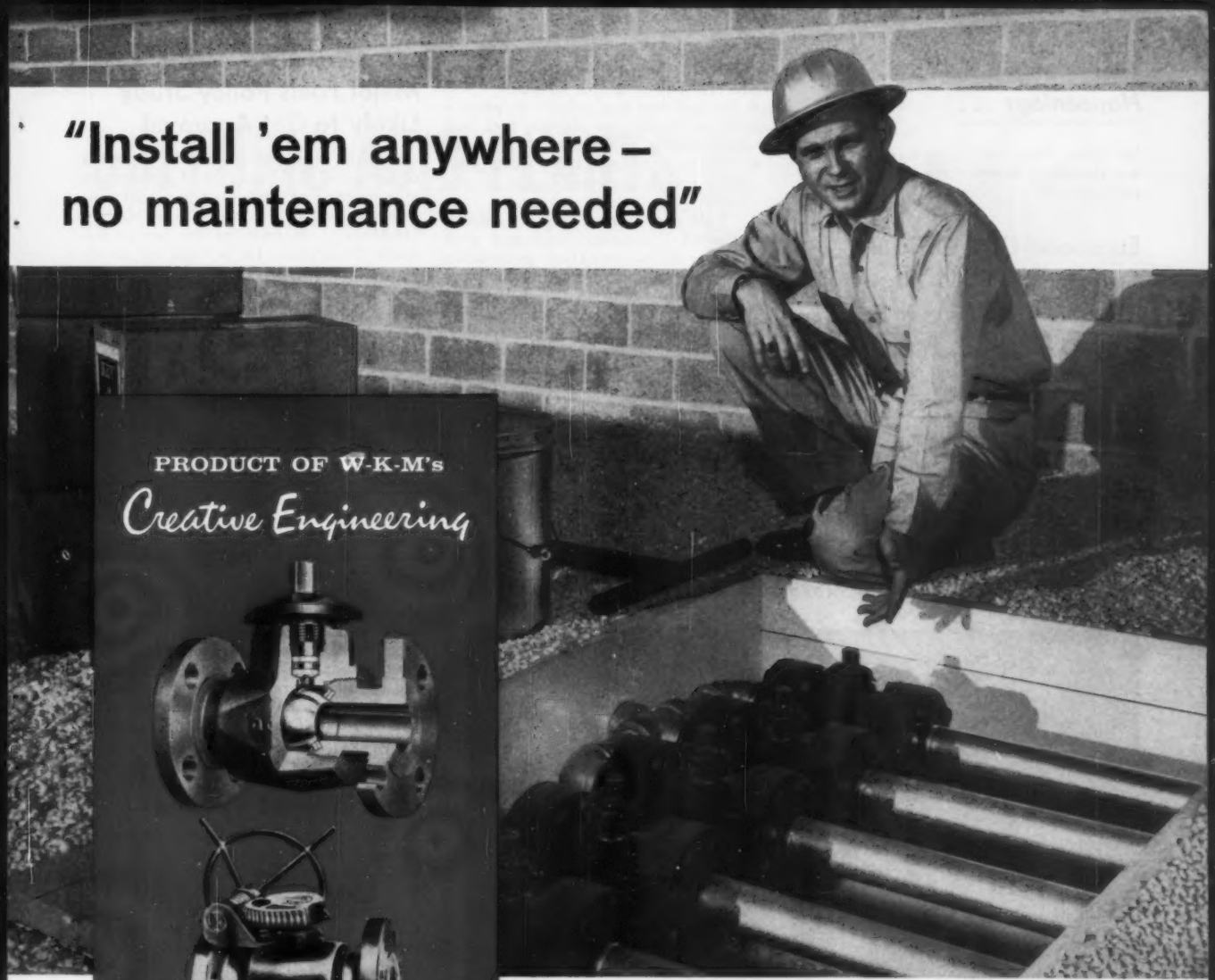
"Install 'em anywhere – no maintenance needed"



PRODUCT OF W-K-M's

Creative Engineering

ACF non-lubricated Ball Valves feature Teflon stem gaskets and seats. There's no lubricant to cause sticking or contamination.

Working Pressures: In carbon steel with ASA ratings of 150 pound and 300 pound, and some sizes in ASA 600 pound; in semi-steel with 200 and 400 pound WOG ratings.

Sizes: ½" through 6". Regular port valves up to 8" x 6".

5922

ACF non-lubricated Ball Valves

ACF Ball Valves are not only non-lubricated . . . but designed *throughout* for maintenance-free performance. For example: The ball is suspended between Teflon* seats under compression for leakproof sealing. Seats are protected from the lading flow. And the full bore conduit provides *smooth* flow, with no destructive turbulence . . . no more pressure drop than through an equal length of pipe.

A quick quarter-turn operates this rugged valve. Specify it. You'll get efficient, economical performance. *Available from leading suppliers everywhere.*

* Du Pont Trademark

WRITE FOR CATALOG 1000

W-K-M

DIVISION OF ACF INDUSTRIES
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P. O. BOX 2117, HOUSTON, TEXAS

but later retracted his remarks regarding the oil industry, stating that he was misinformed.

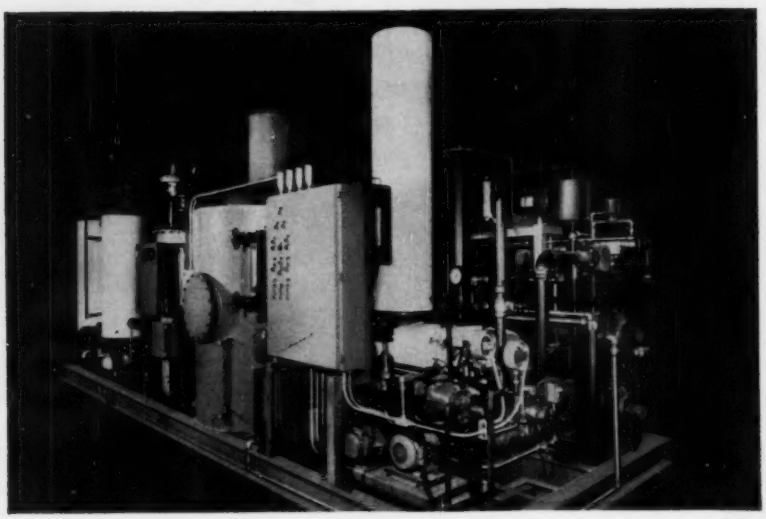
European Coal Officials Seek to Bar Oil's 'Edge'

A series of measures to straighten out the "competitive situation" between coal and gas has been called for by a European Common Market Committee of German, French, Dutch and Belgian coal producers. The measures include:

- Revised fuel tax policies to place a heavier tax burden on residual fuel, and lesser burden on gasoline.
- Common-market tariffs or a consumption tax on imported crude oil and products.
- Crude and product import controls.
- Extend European coal and steel community rules, requiring publication of prices and authorization for company agreements and mergers, to oil and natural gas.
- Common six-nation import policy, with coordination of taxes on different types of energy in each country, and fair transport charges for each fuel.

gas Atmospheres, inc

THE NATION'S LARGEST MANUFACTURER OF PACKAGED GAS GENERATOR SYSTEMS



Performance Plus floor-saving compactness, trouble-free maintenance and "minute man" service. That's what you get when you specify Gas Atmospheres Packaged Gas Generation Systems.

You get full capacity and the dryness and purity you specified in quality-built packaged units that are set on a common base and completely factory tested prior to shipment. And, you can rely on the best factory trained service team in the business whenever your operation calls for it.

It's this kind of customer service that has made Gas Atmospheres Packaged Generators the most popular units working today. Gas Atmospheres makes a complete line of Packaged Generators for inert, CO_2, nitrogen, hydrogen, reducing and annealing gases. Literature available. Write *Gas Atmospheres, Inc., 20011 Lake Road, Cleveland, O.*

Major Fuels Policy Study Likely to Get Approval

A major fuels policy study by Congress seems more likely because of agreements at a meeting of petroleum and coal representatives with the staff of Sen. Murray (D-Mont.), chairman of the Senate Interior Committee. He is expected to revise a resolution pending before the Senate Rules Committee, which would create a special joint committee of Congress to study possible adoption of a national fuels policy.

The National Coal Policy Conference is lobbying for the resolution's passage. The measure, as it currently stands, would establish a special Senate-House Committee to study the long-range fuels situation, and set a guideline for a committee aimed at a national fuels policy that would restrict oil and gas competition with coal and insure coal's markets. The new resolution, however, would drop most of these objectional features, weakening arguments against the measure.

The general feeling in Congress is that the resolution will likely be approved if some sections are toned down enough to merit equitable study. Oil and gas spokesmen have taken the position that standing committes are adequate to undertake any fuels study, but don't object to a special study if the resolution is changed.

Annual MCA Meet to Be Held in West Virginia

The annual meeting of the Manufacturing Chemists' Association will be held June 9-11 at The Greenbrier Hotel, White Sulphur Springs, W. Va. Howard S. Bunn, president of Union Carbide Corp., is program chairman for the meeting. The speakers and program will be announced at a later date. More than 800 chemical industry executives attended the 1959 meeting.

1959 Is Record Production Year for British Plastics

A record production year was seen in 1959 by the British plastics industry, and manufacturers are confident of reaching new peaks this year. The 1959 output is estimated at 495,000 tons, about 20 percent higher than in 1958. This is the highest rate of annual increase recorded in several years. British plastics exports last year (155,000 tons) were more than 25 percent higher than in 1958. Domestic consumption (395,000 tons) was 15 percent higher.

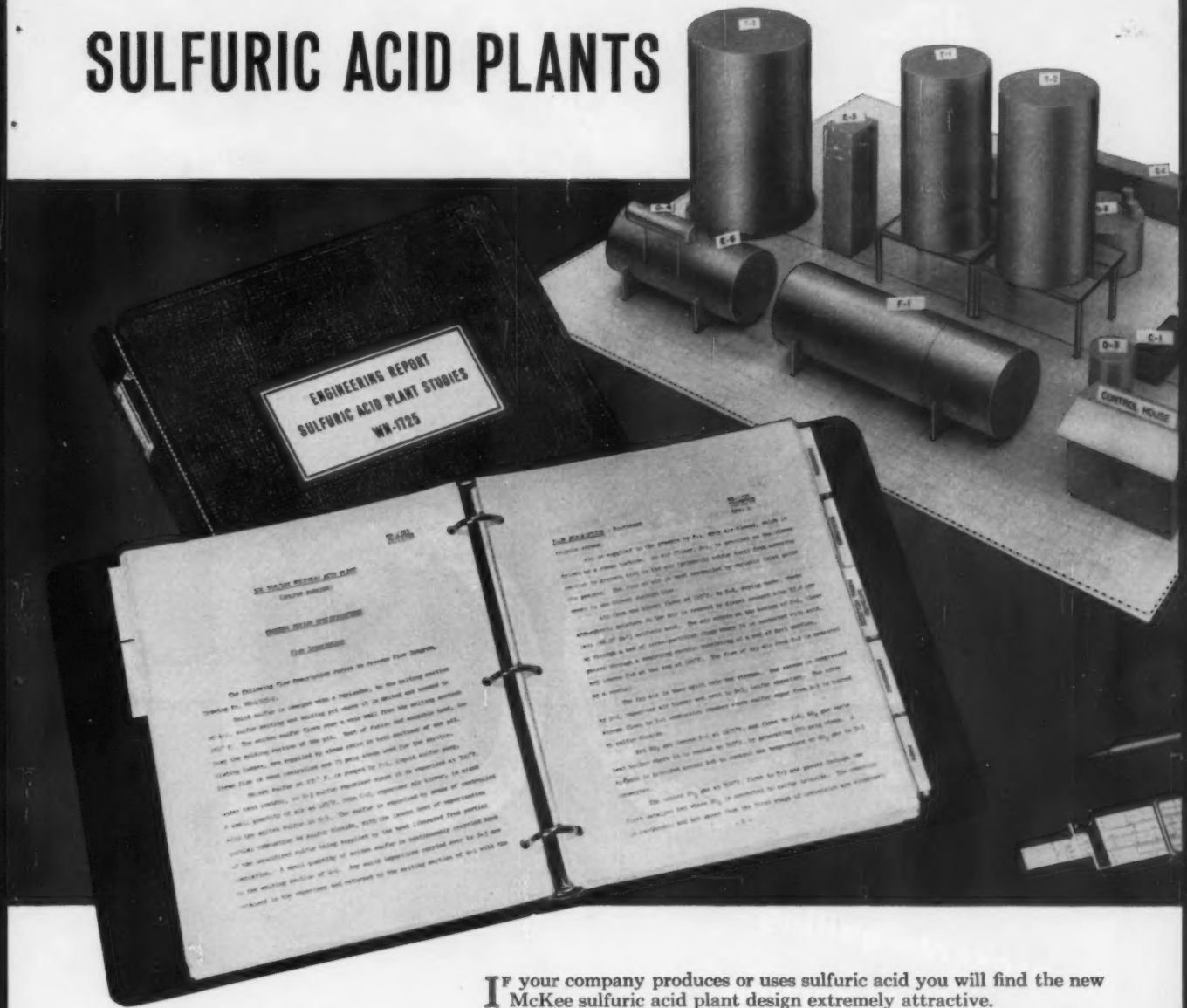
Polyolefins did better than any other plastics. Polyethylene was substantially higher at 85,000 tons, and a new plant brought on stream late last year should raise total capacity to 125,000 tons. Little is being done in polypropylene, but Imperial Chemical Industries, Ltd., will complete a big plant this year.

British polyethylene consumption in 1959 was 50 percent higher than in 1958, at 67,000 tons. Polyvinyl chloride output hit 93,000 tons, compared with 80,000 in 1958. Polystyrene production

For more data on advertised products, use Readers' Service Cards, last page.

NEW McKEE DESIGN CUTS COST OF

SULFURIC ACID PLANTS



IF your company produces or uses sulfuric acid you will find the new McKee sulfuric acid plant design extremely attractive.

The new design is based on comprehensive engineering studies. It was developed following our experience in designing and constructing several recently-completed plants for the production of sulfuric acid from various raw materials. The diversified knowledge and long experience of the McKee organization in steel producing and petroleum and chemical processing facilities were prominent factors in creating this economical, efficient, new design.

McKee now offers sulfuric acid plants which employ important cost-cutting features. The impressive reduction in over-all plant cost and the improvement in plant operation can mean substantial savings to your company. McKee also offers Nitric Acid plants incorporating Uhde's design knowledge and experience. We will welcome an opportunity to give you complete information.

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HEAD, WRIGHTSON & COMPANY, LTD. (BRITISH REPRESENTATIVES OF THE McKEE METALS DIVISION.)

Swagelok® GOOP®

prevents galling
prevents seizing
protects valuable equipment

GOOP is the amazing new compound for ending the costly galling, seizing and resultant destruction of threaded parts.

The line includes three separate products: Blue GOOP, Silver GOOP and High Purity GOOP.

Silver Goop® is formulated to prevent seizing and galling of threaded parts, regardless of applied load, at temperatures up to 2100° F. It reduces take-up torque on threaded parts. Will not drip off red-hot surfaces nor give off poisonous metal or oxide fumes at high temperatures. Resists water washout.

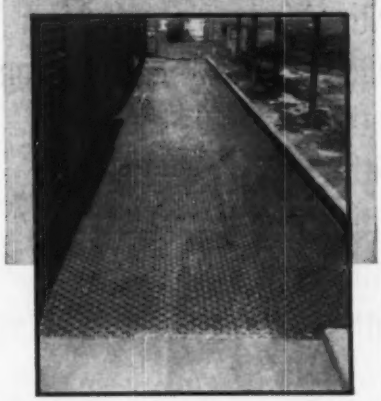
Blue Goop® is an anti-seize and sealing compound for use on titanium, stainless steel, steel, aluminum and high temperature alloys. Withstands temperatures up to 400° F. Impervious to water washout, most acids and all petroleum solvents.

High Purity Goop® is an anti-seize and sealing compound for titanium, stainless steel, steel, aluminum and high temperature alloys. Withstands temperatures up to 400° F. Impervious to moisture, high voltage and cyclic thermal stress. Recommended for use wherever prevention of product contamination is an important factor.

CRAWFORD FITTING COMPANY
884 East 140th Street
Cleveland 10, Ohio
Crawford Fittings (Canada) Ltd., Niagara Falls, Ontario, Canada

LOADING PLATFORMS MUST BE

TOUGH
CLEAN
DRY



The impact of heavy objects can quickly ruin loading platforms and develop hazardous and inefficient working surfaces.

A loading platform made of steel mesh grating cannot splinter like wood or crack and chip like concrete. Steel bars on edge take the impact and the severe abuse. Irving Grating Platforms can not collect snow, water or spilled liquids. They are durable and safe, easy to install and maintenance free.

Manufacturers of Riveted, Pressure-Locked, Welded Gratings in Steel, Aluminum and other metals.

"A Fitting Grating for Every Purpose"

IRVICO

IRVING SUBWAY GRATING CO., Inc.
Originators of the Grating Industry

Offices and Plants at
5090 27th St., LONG ISLAND CITY 1, N. Y.
1890 10th St., OAKLAND 23, CALIFORNIA

is expected to go to 60,000 tons this year, from the 40,000 recorded in 1959, through new plants to be completed this year.

- Changing Times -

Israel's Haifa refineries are selling 700,000 tons of refined oil products to Dutch oil firm in first big deal. Contract will allow refineries to expand production—confined several years to under 1.3 million tons a year for local consumption.

Agreement for joint testing and commercial development of new compounds has been signed by Catalin Chemical Corp. and The Dow Chemical Co. Dow will test Catalin chemicals—give latter analytical report. Catalin looks for resulting speedup in new-chemical creation and market development.

Hercules Powder Co. is distributing $1,110,000 in unrestricted grants-in-aid **among 30 colleges and universities** for chemical engineering, chemistry, physics, mechanical engineering and other areas.

For second consecutive year, enrollment in U.S. accredited engineering colleges has dropped. Last fall, 240,063 registered. In fall 1958, total was 249,950, and in fall 1957, there were 257,777. In 1959, there were 41,132 engineering degrees awarded.

"Methane Pioneer," **well-known tanker that first delivered liquid methane by sea, made final trial delivery to Britain in March,** completing seven trial voyages. **Vessel has delivered more than 12,000 tons** since maiden methane voyage.

Oronite Chemical Co. is acquiring from General Electric Corp. **resin manufacturing and laboratory facilities at Anaheim, Calif.** Plan will continue making alkyd and polyester resins and develop new formulations and applications.

OCAW said on recent anniversary that membership has increased 6.5 percent since March 1955, when union was formed by old OWIU and UGCCW. Ranks number about 200,000.

United Arab Republic's director of General Petroleum Authority and its general manager of General Petroleum Co., will visit Venezuela and Mexico this month for "discussion on oil questions." UAR seeks to form closer political, economic ties with Latin America, says government.

Spain has budgeted $290 million for nationalized oil industry in five-year industrial plan. About $140 million will go into development of petrochemical industry, and $27 million for refinery installations.

Establishment of special **congressional committee to study question of national fuels policy is aim of Rep. Bailey** (D-W. Va.). Proposed bill would be

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Each with these features:

External Adjustment
Sealed mercury contact
Visible calibrated dial
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Thirteen adjustable operating ranges from −60 +30° to 370-530°F.

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Series D-35 (10A. 115V., 5A. 230V.) Double adjustments for setting both high and low (on-off) operating points.

Series D-535 (close differential type) 5A. 115V., 2½A. 230V.) Double adjustment type for setting both high and low (on-off) operating points.

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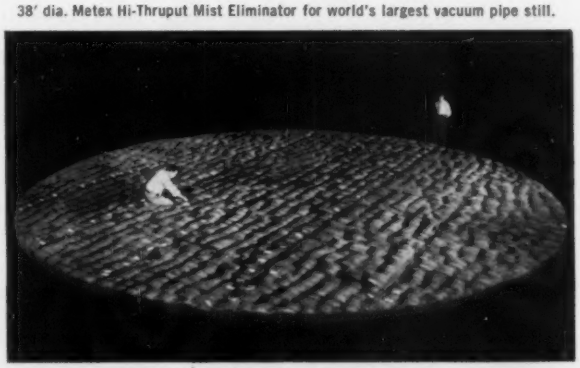
38' dia. Metex Hi-Thruput Mist Eliminator for world's largest vacuum pipe still.



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worded to draw "less opposition than earlier proposition," says Bailey.

New U.S.S.R.-Japan trade pact aims for 1.1 million tons of crude shipments to Japan in 12-month period starting this month, with target upped 55 percent for fiscal 1962. All transactions will be on "commercial basis."

French government-controlled refining and marketing company is being discussed by French ministers of industry and finance. Government wants company for two reasons, (1) **to give own market outlet to government-controlled companies** with Sahara reserves, (2) **government doesn't like idea of having only one French refining and marketing chain,** when, in few years, France will be "major producer."

American Oil Co. says "improved operating methods and curtailed operating volume have reduced manpower needs" at Texas City refinery by about seven percent. Work force will be reduced by about 90 men this month.

New synthetic jet plane oil, which military can store in tropical areas for five or more years without deteriorating, **has been developed by Esso Research and Engineering Co.** Currently being supplied in large quantities, oil **is believed to have highest storage stability of any jet oil ever developed.**

Input of crude oil at Tidewater Oil Co.'s Delaware refinery was reduced by 12,000 bpd during March. Move was to "combat product oversupply resulting from very warm weather on East Coast."

Bay Petroleum Co. has reduced crude oil runs by 12 percent at its New Orleans refinery. Runs dropped from 25,000 bpd to about 22,000.

United Arab Republic has approved formation of integrated $3-million stock company, to be called Popular Petroleum Co., to explore, produce, refine and market Syrian crude oil.

Know-how for polyethylene production will go to Eastern European countries via Imperial Chemical Industries, Ltd. Licenses will be sold to Poland, East Germany, Rumania and Czechoslovakia. Poland already has $24-million contract for polyester fiber license.

Witfield Chemical Corp. has been formed by Richfield Oil Corp. and Witco Chemical Co., Inc., New York. Company will build dodecylbenzene plant—Richfield to supply raw materials, Witco to market finished product.

Union Oil & Gas Corp. of Louisiana and Texas Natural Gasoline Corp. have approved merger. Continuing corporation will be called Texas Natural Gas Corp. Merger **will likely facilitate expansion into petrochemical field**—presently under study.

Crude runs to stills at Lion Oil Co.'s El Dorado, Ark., refinery have been further reduced about 9 percent, bringing total cutback to 15 percent.

Merger is planned by Huskey Oil Co., Cody, Wyo., and Canadian Huskey Oil Co. Deal involves 3.08 million shares of CHO stock.

International Federation of Petroleum Workers is to add employes of Lebanese Petroleum Co., Lebanon, Madras Petroleum Co., and Petroleum Workers of India. **Third foreign union wouldn't join** because of fear of "reprisals."

The disabling-injury rate in the manufacture of compressed and liquefied gases showed a slight decline in 1959, says Bureau of Labor. The injury rate per million-man-hours worked dropped from 9.9 in 1958 to 9.2 in 1959.

Radiation thermal cracking unit has been advanced by Russian scientists from laboratory to planning stage. Proposed by U.S.S.R.'s Institute of Oil Chemical Synthesis, **method would lower cracking temperature considerably**—increase profitable profit range.

Soviet Union looks for 1960 oil production to reach 2.88-million-bpd average, 280,000 more than 1959. Soviet claims figure will increase to 4.8 million bpd by 1965.

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Corrosion
Inhibition
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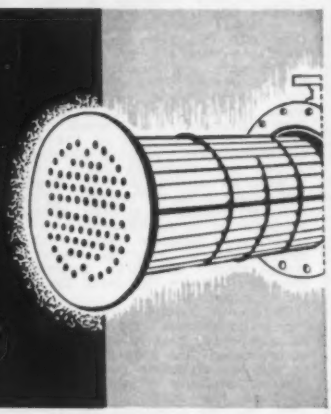

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(*"Income Quotient")

Communicating your convictions gains better understanding, improved relations, greater results for engineers

Breathes there a man with soul so dead, who never to his friend has said, "Don't those lamebrains in the_____ Department every get ANYTHING right? . . . I very carefully wrote EVERYTHING down, very logically and clearly . . . didn't leave a thing out . . . and they still don't get my point!" — or words to that effect?

The only qualification you need for having voiced these sentiments is that you occupy yourself daily with one or more **people**, because it is with **people** that communications break down — people on either end of the chain of communication, whether they be employee or employer, buyer or seller, veteran or newcomer. **(See Footnote)**

Whether it be an internal or external message, verbal or written, a telephone message or a memorandum, a formal report or a business letter, technical or elementary, a progress report or a comparative, scientific analysis, the ground-rules are the same for successful communications.

Take our friend who is beset by "those lamebrains," for instance. Can he be so positive that it was the **other** end of the chain that bogged down? Perhaps he was **too complete** in his instructions, where simplicity would have sufficed. Perhaps the receiver merely needed short, concise directions, not the logical, careful rationalization of the writer. Perhaps his memorandum was clear to **him**, but maybe the "practical examples" he gave weren't so practical to the recipient because it was **outside his frame of reference**, background or experience. Maybe a telephone call would have been a more efficient medium of exchange in this instance.

The basic problem, then, is one of needing to transmit our beliefs, decisions, conclusions from us to someone else, and to have that other person **understand what we mean** — quickly, accurately, simply and — pleasantly.

Perhaps one of the cardinal rules for better communications, then, is **better understanding**: consideration for others, and a **desire** to understand another's viewpoint. Actually, this merely bespeaks the real origin of "fluid communications": **thought**, for thought plays a vital role in what we feel, observe, write, say, or demonstrate; and these **are** the principal means of communication available to everyone: thinking, feeling, observing, writing, saying, demonstrating. **(See Footnote)**

Does this sound like a monumental, life-long task? It is, and it isn't. It is **not** monumental unless you make it so by resenting it, and it **is** life-long, because as you change, as others change, as business changes, so do communication forms, vocabularies, meanings, frames of reference.

It is not sufficient in a competitive economy to **have** convictions; it is necessary to **sell** your convictions to someone who can either do something with them, or authorize you to do so. This, then is one of the chief values of communications; to help you accomplish your aims in engineering, in your professional life, more quickly, more productively, more successfully. Combined with your technical knowledge, your ability to perform and deliver, and your initative, communications can become the most valuable tool in your professional "workshop."

FOOTNOTE: For more detailed information on this subject, write for "Fluid, Fluent Communications," to WESTERN SUPPLY COMPANY, HEAT EXCHANGER DIVISION, P. O. BOX 1888, TULSA, OKLA. — and if there's a heat exchanger in your company's future, we'd appreciate a "line of communication" from you!

Meetings Calendar

April	
19–21	**Southwestern Gas Measurement Short Course,** Drill Hall, North Campus, University of Oklahoma.
20–22	**National Petroleum Association,** Semiannual Meeting, Hotel Cleveland, Cleveland.
20–22	**Texas A. & M. Symposium,** Instrumentation for the Process, College Station, Texas.
21–22	**American Society of Mechanical Engineers-SAM,** Management Conference, Statler Hilton Hotel, New York.
25–26	**ASME,** Maintenance and Plant Engineering Conference, Chase-Park Plaza, St. Louis.
25–29	**American Welding Society,** Annual Meeting and Welding Exposition, Los Angeles.
27–29	**NGAA,** Annual Convention, Rice Hotel, Houston.
May	
2– 6	**American Petroleum Institute,** Midyear Meeting, Safety and Fire Protection Committees, Atlanta-Biltmore Hotel, Atlanta.
9–11	**Instrument Society of America,** Power Instrumentation Symposium, San Francisco.
9–12	**API,** Midyear Meeting, Division of Refining, Statler and Sheraton-Cadillac Hotels, Detroit.
9–13	**American Society for Metals,** Southwestern Metal Congress and Exposition, Sheraton and Other Hotels, Dallas.
16–20	**National Fire Protection Association,** Annual Meeting, Queen Elizabeth Hotel, Montreal, Canada.
22–26	**ASME,** Oil and Gas Power Conference and Exhibit, Muehlebach Hotel, Kansas City, Mo.
22–26	**Air Pollution Control Association,** Annual Meeting, Netherland-Hilton Hotel, Cincinnati.
23–26	**Design Engineering Show,** New York Coliseum.
26–27	**Rocky Mountain Oil & Gas Association,** Annual Meeting, Refining Committee, Newhouse Hotel, Salt Lake City, Utah.
June	
1–3	**Southern Gas Association,** Annual Short Course in Gas Technology, Lewis Hall, Texas College of Arts and Industries, Kingsville, Texas.
5–10	**ASME,** Semi-Annual Meeting and Aviation Conference, Statler Hilton Hotel, Dallas.
5–10	**Society of Automotive Engineers,** Summer Meetings, Edgewater Beach Hotel, Chicago.
13–15	**American Association of Cost Engineers,** National Meeting, Rice Hotel, Houston.
15–16	**Western Petroleum Refiners Association,** Mid-Continent Regional Technical-Industrial Relations Meeting, Hotel Lassen, Wichita, Kan.
19–22	**AIChE,** Meeting, Del Prado Hotel, Mexico City.
26-Jul 1	**American Society for Testing Materials,** Annual Meeting and Apparatus Exhibit, Chalfonte-Haddon Hall, Atlantic City.
Aug.	
15–17	**ASME-American Institute of Chemical Engineers,** Heat Transfer Conference and Exhibit, Statler Hilton Hotel, Buffalo, N.Y.
Sept.	
14–16	**National Petroleum Association,** Annual Meeting, Hotel Traymore, Atlantic City.
15–16	**ASME,** Engineering Management Conference, Hotel Morrison, Chicago.
18–21	**ASME,** Petroleum Mechanical Engineering Conference, Jung Hotel, New Orleans.
21–23	**ASME-AIEE,** Power Conference, Bellvue-Stratford Hotel, Philadelphia.
25–28	**AIChE** Meeting, Mayo Hotel, Tulsa.
25–28	**American Institute of Electrical Engineers,** Electrical Conference of the Petroleum Industry, Hotel Skirvin, Oklahoma City.
Oct.	
9–12	**ASME,** Rubber and Plastics Conference, Lawrence Hotel, Erie, Pa.
10–11	**ASME-AIEE,** Fuels Conference, Daniel Boone Hotel, Charleston, W. Va.
11–14	**National Association of Corrosion Engineers,** Northeast Region Conference, Prichard Hotel, Huntington, W. Va.
13–14	**California Natural Gasoline Association,** Fall Meeting, Hotel Miramar, Santa Monica, Calif.
25–28	**National Association of Corrosion Engineers,** South Central Region Conference, Mayo Hotel, Tulsa.
Nov.	
27–Dec. 2	**ASME,** Annual Meeting, Statler Hilton Hotel, New York.
Dec.	
4– 7	**AIChE** Meeting, Hotel Statler, Washington.
7–11	**NACE,** University of Illinois Corrosion Control Short Course, Urbana Campus.

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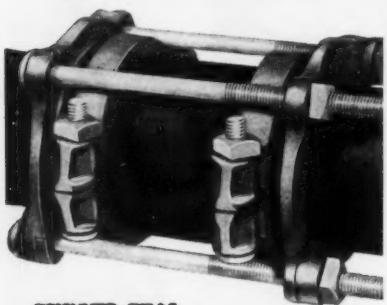

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"Handbook of Industrial Research Management" brings together in one volume the best practice in the organization, evaluation, and control of industrial research. It provides professional guidance for purposes of competitive survival, growth and diversification. Here is clarification of a management function which has proven least amenable to confident long-range allocations and effective operating controls. More than 30 experts with long and successful records in research management spell out the problems, and how they are solved. Top management, directors of research and their assistants, and financial executives—all will find here a cohesive and specific treatment of this important subject.

(Heyel, Carl (editor), *Handbook of Industrial Research Management,* Reinhold Publishing Corp., 520 pages, $12. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas.)

Centrifugal Pumps

"Centrifugal Pumps for General Refinery Services, Third Edition" (API Standard 610) has been published. This standard covers the minimum requirements for centrifugal-type pumps for petroleum products, including single-case horizontal and single and double case vertical pumps. It does not include heavy-duty, double case horizontal pumps.

(API, *Centrifugal Pumps for General Refinery Services, Third Edition,* (API Standard 610), American Petroleum Institute, 1271 Avenue of the Americas, New York 20, N.Y., 26 pages, $1.50.)

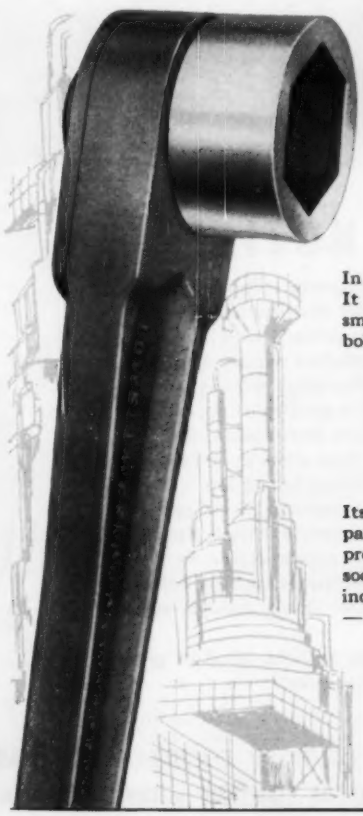
Idle Equipment Protection

"Guide for Inspection of Refinery Equipment," (Chapter 18, Protection of Idle Equipment) has been published. This first edition, 1959, includes a consideration of the basis of protection, the methods of protection, and procedures for protection of specific refinery equipment.

(API, *Guide for Inspection of Refinery Equipment (Chapter 18, Protection of Idle Equipment),* American Petroleum Institute, 1271 Avenue of the Americas, New York 20, N.Y., 20 pages, $1.)

Coke & Chemistry, USSR

"Coke & Chemistry, USSR," a monthly Russian journal, will be of interest to engineers, chemists, and all technical personnel interested in coal carbonization for the production of metallurgical and gas coke, and in the recovery and refining of coking by-products. Of special interest is information given on current advances in Russian coking technology. The book, translated into English, is supported by the Department of Scien-



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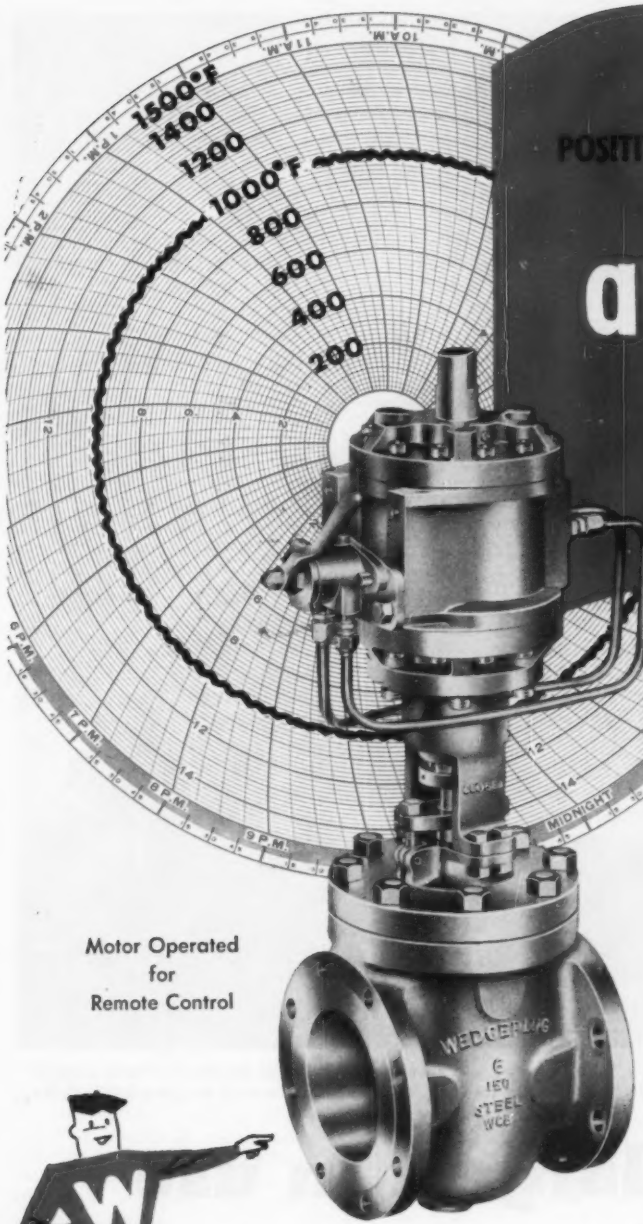

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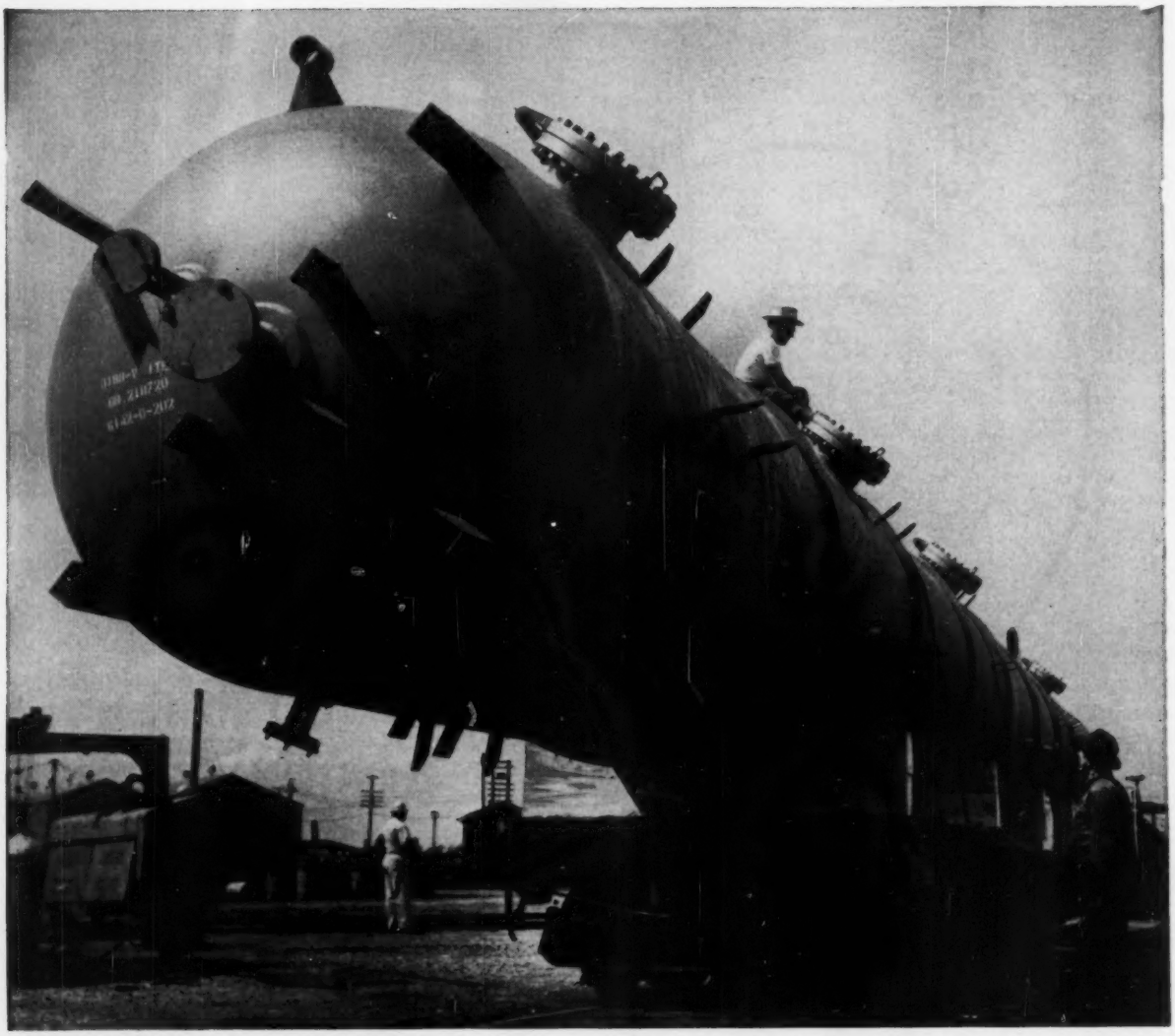

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tific and Industrial Research (England) and is produced by the Coal Tar Association and the British Coke Research Association.

(USSR, *Coke & Chemistry, USSR*, Coal Tar Research Association, Oxford Road, Gomersal, NR Leeds, England, $3 per issue, $16 per year, $21 per 17 issues from August 1959-December 1960 (50 percent off for university and college libraries.)

Instrumentation Abstracts

"Instrumentation Abstracts", a new comprehensive abstracting service covering the field of instrumentation, has been inaugurated. The scope of the service will include:

- All articles dealing with instruments and instrumental methods of analysis, as used for the determination of chemical composition or product quality, in the laboratory or on-stream.
- All articles dealing with instruments and instrumental methods of measuring physical quantities such as temperature, pressure, flow, viscosity, density, etc.
- All articles dealing with instruments for process control including those describing transducers, controllers, and final control elements.

The service will search:

- Articles in American and selected foreign technical journals covering developments in instrumentation.
- Papers presented at technical meetings in so far as they can be obtained.
- U.S. patents and selected foreign patents.
- Books as issued.

The abstracts will be furnished on 5x8-inch Unisort punched cards. These are classified by notching and sorted by use of a needle. A classification system will be provided to facilitate handling the cards and the cards will be marked with code numbers corresponding to this system.

(Lowry, C. D. Jr., and Preston, S. T., Jr., *Instrumentation Abstracts*, 80 East Jackson Blvd., Chicago 4, $600 per year.)

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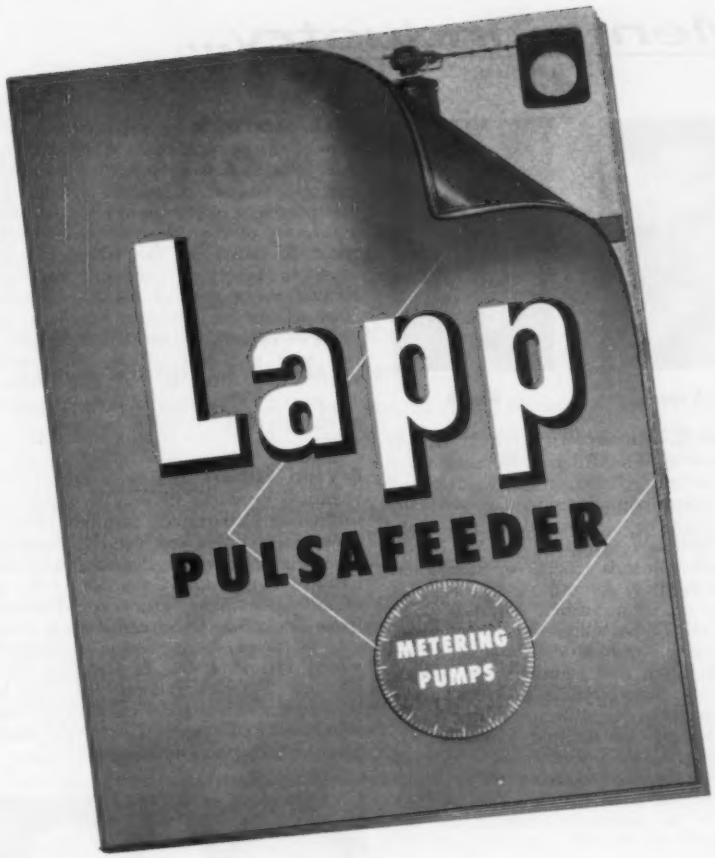
For a free copy of our book catalog write to BOOK DEPARTMENT, GULF PUBLISHING COMPANY, P. O. Box 2608, Houston 1, Texas. Often books reviewed here may be purchased from this source.



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Men In Industry...

Milner

Kusch

Byron E. Milner has been appointed manager of The Atlantic Refining Co.'s Port Arthur, Texas, refinery. He had been general superintendent of the plant since 1957. Milner succeeds **Paul L. Robison,** who is retiring. **Albert W. Kusch** succeeds Milner as general superintendent of the refinery. A graduate of the University of Pennsylvania, Milner joined the firm's Philadelphia refinery in 1939. After assignments in the Manufacturing and Research and Development departments, he transferred to Port Arthur in 1956 as technical assistant to the manager. In 1957 he became general superintendent. Kusch joined Atlantic in 1941 following graduation from MIT. Since 1959 he has been at the Port Arthur refinery as technical assistant to the manager.

William M. Creasy (Maj. Gen., U.S.A., Ret.) a vice president of The Lummus Co., has been appointed manager of the company's New York Division. At the same time, **Dr. S. Z. Avedikian** is joining the company as acting director, Engineering Development Center, Newark, N.J., succeeding Gen. Creasy. Before joining Lummus, Gen. Creasy was chief chemical officer of the Army. He is a registered professional engineer in New York, New Jersey, Maryland, and the District of Columbia. Before joining Lummus, Dr. Avedikian was co-founder of Avedikian and Co. in 1932, Tidings Corp. of America in 1947, and S. Z. Avedikian & Associates in 1959. He has engaged in the research and development of processes and products for 25 years.

Vance A. Knight, Houston, has been named assistant manager of Continental Oil Co.'s Industrial Relations Department, Houston. Formerly administrative assistant in the department, Knight joined the Controller's Department at Ponca City, Okla., in 1948 and transferred to Houston in 1950. He was an analyst in the Industrial Relations Department for two years and later became assistant manager and manager of industrial relations, Southwestern Region, Fort Worth. He moved to Denver in 1957 as manager of industrial relations for the Rocky Mountain Region and returned to Houston in 1958 as administrative assistant, Industrial Relations Department.

W. L. Martwick has been elected chairman of the board, Foster Wheeler Corp., and **John E. Kenney** president and chief executive officer. **Clark P. Lattin, Jr.,** vice president in charge of sales, becomes a director of the corporation. Martwick spent 33 years in the Sales Division prior to becoming president in 1958. Kenney spent most of his 22-year company career in Chicago in charge of midwest operations, and has been executive vice president of the corporation since 1958. Lattin, in the Sales Division 15 years, was appointed vice president in charge of the division last year.

Bryson Filbert has been appointed chemical products advisor, Refining Coordination Department, Standard Oil Co. (New Jersey). He was formerly manager of manufacturing in Bogota for International Petroleum (Colombia) Ltd., an affiliated company. After graduating from Penn State University with a degree in chemical engineering in 1936, he joined Humble Oil & Refining Co.'s Baytown, Texas, refinery. In 1947 he became division head of research and development at Baytown. Filbert was made manufacturing coordinator in 1956.

Oman

Smith

Clifford E. Oman has been named assistant to the director of production, U. S. Industrial Chemicals Co. He was previously Tuscola general manager with responsibility for operations of USI's petrochemical plant complex at Tuscola, Ill. He has been at the Tuscola plant since 1951 when he joined the staff as an area superintendent. **James R. Smith,** plant manager, assumes responsibility for Tuscola plant operations. He had been plant manager of USI's caustic-chlorine plant at Huntsville, Ala., from 1951-57. He was also plant manager of the zirconium-titanium metals plant and production manager in the New York headquarters.

Howard S. Bunn, president of Union Carbide Corp., has been named chairman of Lehigh University's committee on business and industry. The committee, comprised of 100 industrial leaders, was founded in 1952. Bunn has B.A. and chemical engineering degrees from Lehigh, and has been with Union Carbide since 1922.

Louis H. Huth has been appointed manager of operations of Amoco Chemicals Corp. He will be in charge of plants at Joilet, Ill.; Texas City; and Seymour, Ind. **Frank Allen Upson** has been appointed manager of engineering, and will be responsible for engineering and construction of new plant facilities and other major projects. For more than three years Upson has been chief engineer in the Process Engineer Division, General Engineering Department, Whiting refinery, Standard Oil Co. (Indiana). He held various design and other engineering positions in Standard's Manufacturing Department from 1939-56. Huth has been superintendent of operations in the Mandan, N. D., refinery of Standard Oil Co. (Indiana) since 1954. He had previously worked in the Manufacturing Department at Whiting and Sugar Creek refineries.

Lawrence L. Smith has been appointed general manager of manufacturing, Amoco Chemicals Corp. He will be in charge of all manufacturing operations, of engineering and construction of manufacturing facilities, and of supply and transportation. He continues as a director of the corporation, a position he has held since 1957. For the past year Smith has been on an assignment in connection with the formation of Amoco Fina S. A. by Petrofina S. A. of Belgium, and Amoco. He has been active in the petroleum and petrochemical industries for 35 years.

C. E. Leach has been elected a vice president of industrial relations for Texas Butadiene & Chemical Corp. He was formerly director of industrial relations. Leach received his M.S. degree from the University of Michigan and joined Texas Butadiene & Chemical in 1955 as director of industrial relations. He was previously with Celanese Corp. of America from 1945-55, serving as personnel superintendent, Chemical Division. He will headquarter in Houston.

R. W. Faulk, manager of Shell Oil Co.'s Norco, La., refinery, has been named manufacturing vice president of Shell Oil Co. of Canada, Ltd. Faulk, whose appointment becomes effective July 1, will succeed **G. Davidson,** who will retire June 30. **L. T. Wilson,** manager of Shell of Canada's Montreal refinery, will succeed Faulk at Norco. Faulk joined Shell at the Houston refinery in 1929 after graduation from Southwestern Louisiana Institute with a degree in chemical engineering. Wilson joined Shell in 1933 at the Wilmington-Domin-

Faulk

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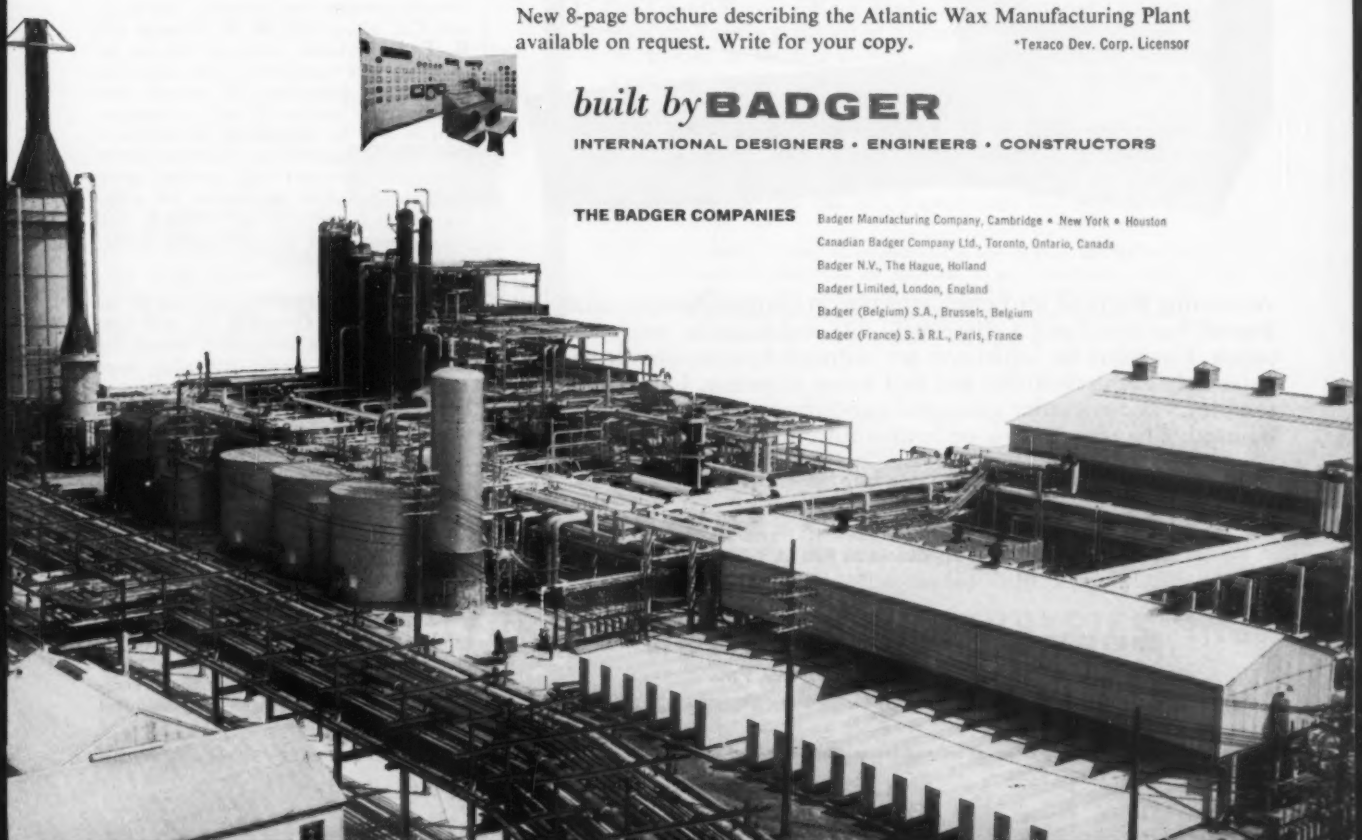

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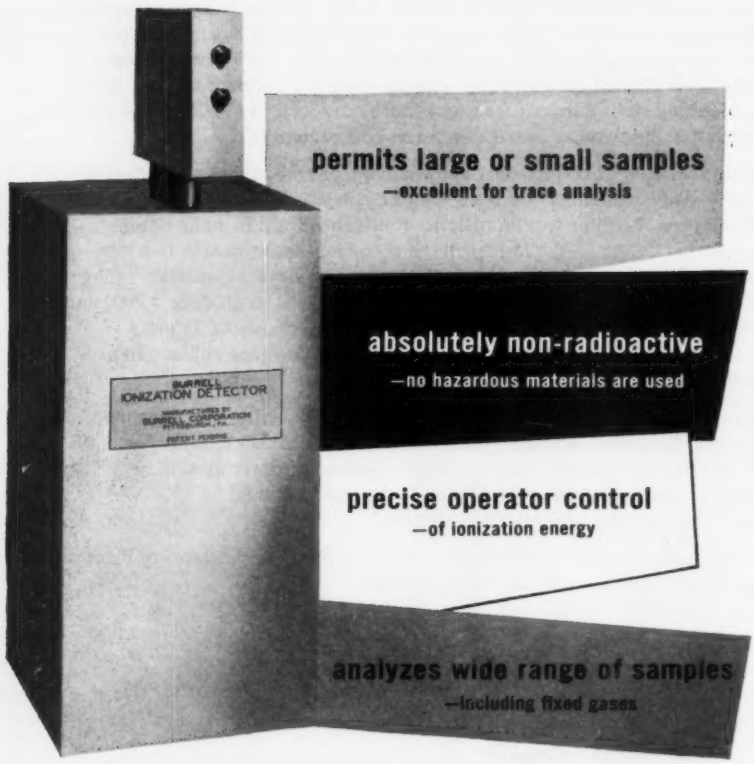

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Men . . .

guez, Calif., refinery as a junior tester, and was named to his present post in May 1959. He has a degree in geology from Oregon State College.

B. A. Vallerga has been named director of products engineering for Golden Bear Oil Co. He will supervise and direct engineering and promotional activities relating to applications and uses of petroleum products in soil conservation and highway construction. For seven years Vallerga has been managing engineer of the Asphalt Institute, Pacific Coast Division, Berkeley, Calif. He supervised and directed engineering, educational, and research activities of the institute in several states.

Vallerga

Paul T. Atteridg has been named manager, Refinery Plans Division, The M. W. Kellogg Co. He will supervise a group of specialists planning new processing installations. Atteridg was previously section head, process development, in Kellogg's R & D laboratories, Jersey City, N. J., where he was in charge of pilot plant experimentation. With the company since 1947, Atteridg holds chemical engineering degrees from Cornell University, and did post graduate work in Brooklyn Polytechnic Institute.

M. D. Gilchrist has been elected a senior vice president of Universal Oil Products Co., along with **M. R. Schrein** and **R. E. Sutherland.** Gilchrist will be responsible for commercial development, engineering, petrochemical process sales and market research and economics. Schrein will be responsible for chemical research, manufacturing, chemical products development and product sales. Sutherland will be responsible for refining research, engineering research and development, and the company's Riverside, Ill., pilot plant.

Dr. Earl W. Bennett, chairman of the board, The Dow Chemical Co., was honored recently at a testimonial dinner for his 60-year Dow career. Attending were 150 guests from all parts of the country. Dr. Bennett, 80, joined Dow in 1900 as office boy. He soon became bookkeeper —then rose in responsibility and influence over the company's financial affairs. He became a director in 1927, vice president in 1931 and treasurer in 1934. He has been board chairman since 1949.

J. F. Cooper, formerly supervisor, Process Development Section, at Jefferson Chemical Co.'s Austin, Texas, laboratories, has been made assistant to the vice president for research and development, Houston. He is a chemical engineer with a M.S. degree in chemical

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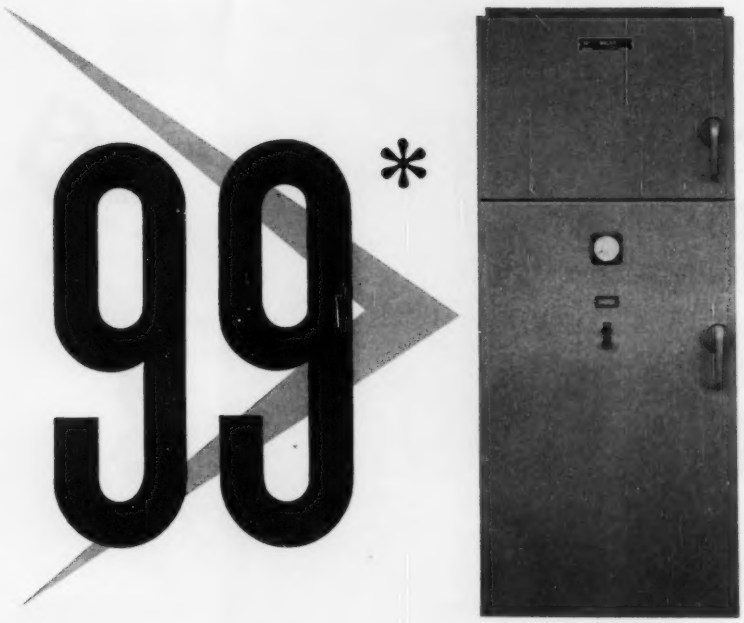

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Men . . .

engineering from The University of Texas. **H. G. Muhlbauer,** previously senior research chemical engineer, becomes supervisor, Process Development Section. Muhlbauer has a B.S. degree in chemical engineering from Cooper Union and M.S. degree in chemical engineering from the University of Delaware. **L. P. Benthack,** formerly senior research specialist, is appointed supervisor, Semi-Works Section, Austin Laboratories. He holds degrees in chemical engineering and petroleum refining from the universities of Nebraska and Pittsburg respectively.

Donald O. McCarthy has been named assistant production manager, polyethylene resins by U. S. Industrial Chemicals Co. He joined USI in 1956 as a technologist, Tuscola, Ill., plant. Before the new appointment, he was an area superintendent. McCarthy attended the University of Nebraska and received a B.S. degree in chemical engineering. Before joining USI, he was with the Girdler Construction Co., Louisville, Ky.

McCarthy

Clark A. Gruver has been appointed assistant manager of Mobil Oil of Canada, Ltd., Libyan Branch, Tripoli, Libya. He joined Mobil in Venezuela after graduation from the University of Oklahoma in 1939 with a degree in petroleum engineering. He served in both Venezuela and Colombia before becoming manager of services for Mobil Oil de Venezuela in 1958.

Darwin W. Ferguson has been elected president and director of Sun Oil Co., Ltd., Toronto, Ont. Previously manager of the parent Sun Oil Co.'s Southeastern Sales Region, Jacksonville, Fla., he succeeds **Wilburn T. Askew.** Askew will return to Sun's Philadelphia office and will continue with Sun Oil, Ltd., as a vice president.

Lawrence W. Heptig has been appointed assistant labor counsel of Olin Mathieson Chemical Corp. He previously was assistant manager of industrial relations of the company's E. R. Squibb & Sons Division. He joined Squibb in 1951, where he was personnel manager of the New Brunswick, N. J., plant. Heptig has a B.S. degree in industrial relations from Cornell University, and is a graduate of St. John's Law School.

Dudley P. Penick has been appointed staff gas engineer for Mobil International Oil Co., New York. He will have staff responsibility for gas production processing, separation and utilization in all Mobil International operations. Penick had been with Magnolia Petroleum Co.'s Natural Gas Department since 1949—

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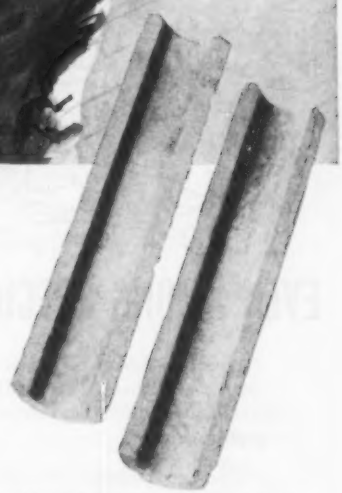

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Men . . .

most recently as a process engineer in Dallas. For the past six months he has been with Mobil Oil Co. de Venezuela.

James W. Bateman has been promoted to assistant manager of Continental Oil Co.'s Lake Charles, La., refinery. He formerly was assistant manager of the company's Coordinating and Planning Department. Bateman joined Conoco in 1952 at Houston as technical assistant to the manager of manufacturing. He became director of the new projects division, coordinating and planning department, in 1956 and was promoted to assistant director, coordinator and planning, in 1959.

Frank T. Grassy has been elected a vice president of Great Northern Oil Co. A former FBI agent and industrial relations director for Miller Brewing Co., Milwaukee, Grassy joined Great Northern in June 1958 as manager of industrial relations. He will continue to hold that title in addition to new duties as vice president.

Howard J. Grady has been named president and director of California Spray-Chemical Corp. Formerly executive vice president of Calspray, he also becomes president of Ortho Agricultural Chemicals, Ltd., of Canada. A graduate of the University of Kansas, Grady joined Calspray in 1926 as a research entomologist.

Dr. Charles A. Stokes has joined Columbian Carbon Co. as general manager of research and development, Carbon Black and Pigment Division. Dr. Stokes, whose specialization is in carbon black and petrochemical research, joins Columbian from Texas Butadiene and Chemical Corp. He is a chemical engineering graduate of the University of Florida and MIT, where he was on the teaching staff. He is a member of ACS and AIChE. Dr. Stokes will headquarter at Columbian Research Laboratories, Princeton, N. J.

Stokes

C. L. Suhr, who has spent more than 50 years of service as a director of The British American Oil Co., Ltd., has received special recognition from the company. B-A **President E. D. Loughney** presented Suhr with a sterling silver tray during the company's quarterly meeting of directors. The tray is engraved with signatures of all seven presidents the company has had, and all current directors.

James Acquaviva has been named an engineering associate by Esso Research and Engineering Co. He is currently on an assignment at the Esso R & E European office in The Hague, Netherlands. He has been there since April 1959, following the engineering aspects of refinery construction projects for a number of the European affiliates of Standard Oil Co. (New Jersey). Acquaviva is a member of the Construction Engineering Division.

A. Russell Young has been appointed assistant executive vice president and general manager of J. F. Pritchard and Co. After graduation from the University of Kansas, he joined Pritchard as an engineer in 1938 and became manager of the Gas Division in 1944. In 1954, he was appointed vice president in charge of the Gas Division. Young is also vice president of the Constock-Pritchard Liquefaction Corp.

Paul H. Richard, for the last five years automotive liaison representative of E. I. du Pont de Nemours & Co.'s Petroleum Chemicals Division, Detroit, has been named head of a new Automotive Division in the company's Petroleum Laboratory. Succeeding him as Detroit liaison representative is **Max W. Corzilius,** who since 1951 has been attached to the Petroleum Laboratory as a research engineer.

Patrick P. McCall has been appointed a research associate by Esso Research and Engineering Co. With the company since 1952, he holds a professional degree in petroleum refining engineering from Colorado School of Mines. Since join-

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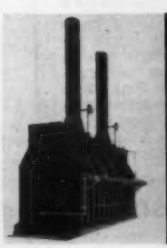

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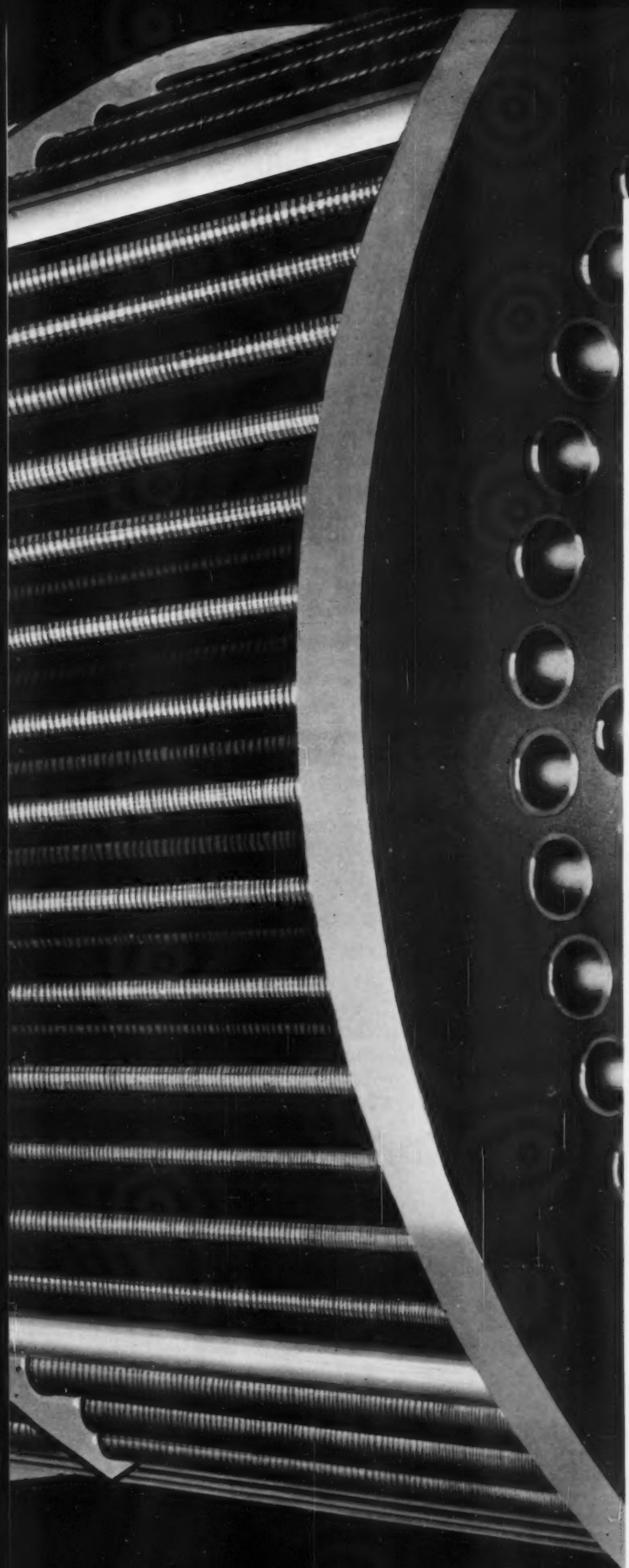

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Men . . .

ing the company he has been in the Process Research Division.

His research activities have been in refinery processes including catalytic and thermal cracking.

Paul E. Kuhl, an assistant general manager of Esso Standard Oil Co.'s Manufacturing Department, has returned to that post from a four-year loan assignment in Iran, where he was general manager of the Abadan refinery. He was an assistant general manager of manufacturing for Esso from 1950 until he went to Iran, except for another loan assignment which took him to Washington for a year. He was with the Petroleum Administration for Defense, first as director of foreign refining and later as assistant deputy administrator. Earlier in his career, Kuhl was manager, Southern East Coast refineries, and assistant general manager, East Coast Manufacturing Division.

Kuhl

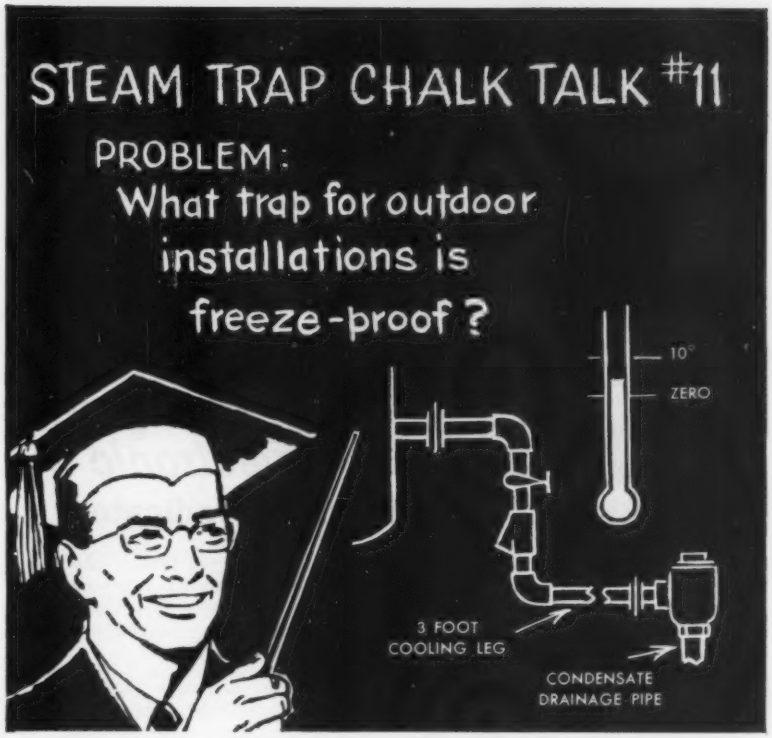
James A. Eanes has been appointed lubrication engineer in charge of technical service in the Lube Oil Sales Section of Monsanto's Lion Oil Co. Division. Headquartered in El Dorado, he will handle and supervise all lubrication technical service. Since 1954 he has been with Arkansas Fuel Oil Corp. as lubrication engineer.

Erhart K. Drechsel has been appointed associate director, Development Department, Texas Butadiene & Chemical Corp., New York. He was formerly with Escambia Chemical Corp., where he was manager of new product development. His experience also includes 12 years with American Cyanamid Co. in various research and marketing positions.

William H. King, Jr. has been named a research associate by Esso Research and Engineering Co. A chemical engineer, he has been with Esso R & E since 1947. He joined the company soon after graduation from Rensselaer Polytechnic Institute. A member of the Analytical Research Division, King formerly was in the Process Research Division.

Dr. Robert Foreman, a member of the professional staff at The Standard Oil Co. (Ohio) Research Center, Cleveland, has been promoted to senior research associate, Research Department. Formerly connected with the University of Michigan and the Manhattan Project, Dr. Foreman joined Sohio in 1946.

John R. Hodson has been appointed associate director of the Development Department, Texas Butadiene & Chemical Corp., New York. A graduate of The



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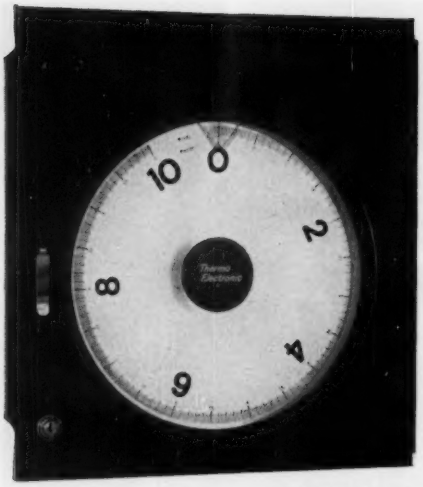

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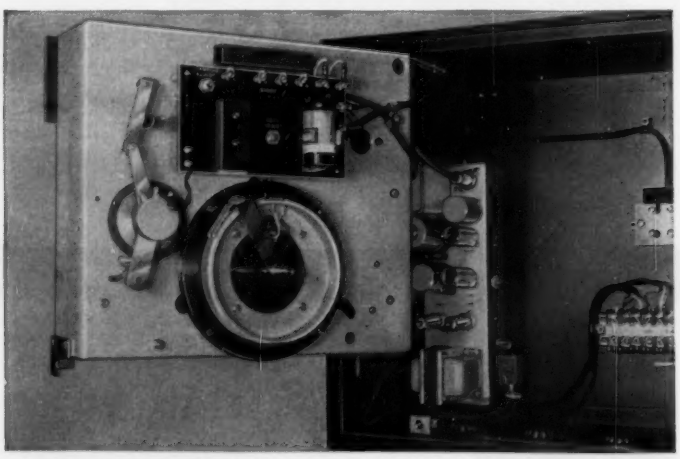

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Men . . .

University of Texas and MIT, he has spent the last three years with TB & C in the Process Economics and Development departments. Before joining TB & C he was wth Humble Oil & Refining Co., Baytown, Texas, where he spent 15 years in various technical sections.

Charles E. Paules, who was primarily responsible for the design and construction of 35 oil refineries around the world, has retired as a vice president of Esso Research and Engineering Co. Paules also served on the board of directors. He was associated with construction of the world's first fluid catalytic cracking unit, built at Baton Rouge in 1942. A civil engineering graduate of Lehigh University, Paules has lectured on the theories and practices of engineering management at various college, technical society and AMA meetings.

Paules

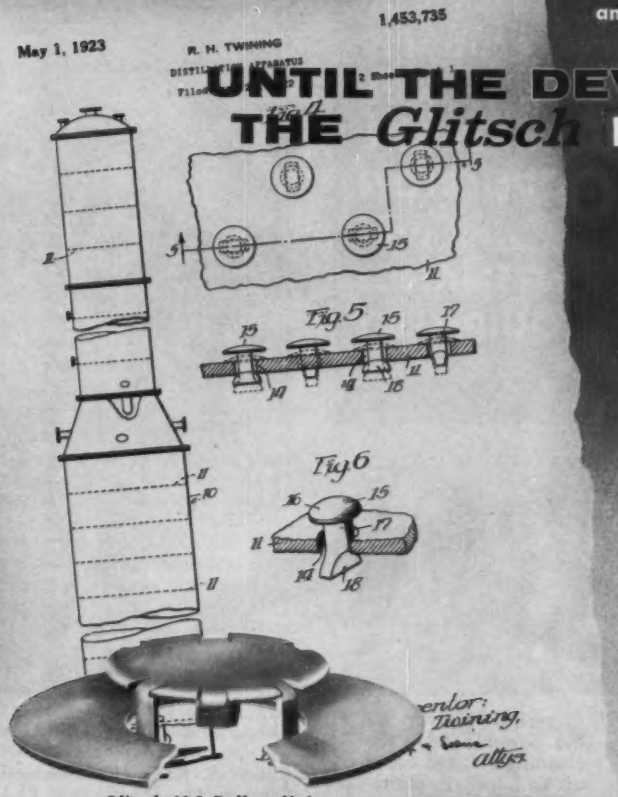
Dr. W. H. Hopson, formerly with Pan American Petroleum Corp., Tulsa, has been transferred to Texas City as section head, Research Section, American Oil Co. **Dr. Isaac Trachtenberg** has been promoted to group leader, Research Section. Dr. Hopson taught chemistry at Southwest Texas State and Stephen F. Austin colleges for seven years after receiving his Ph.D. degree in chemistry from the State University of Iowa in 1935. He joined Pan American Petroleum in 1946. Dr. Trachtenberg joined Amoco at Texas City in 1957, after receiving his Ph.D. degree in chemistry from Louisiana State University.

David Christison, former manager of Mobil Oil Co.'s East Providence, R.I., refinery, has been named manager, Buffalo refinery. **Boris L. Rodzianko,** formerly assistant manager of the Ferndale, Wash., refinery, becomes manager at East Providence. **Wayne A. Howard,** formerly manager of manufacturing coordination and control, becomes manager of engineering and technical coordination, Manufacturing Department. **Paul A. Rene,** formerly with Mobil International Oil Co.'s Supply and Distribution Department, becomes manager of analysis and control, Mobil Oil Manufacturing Department.

James M. Patterson, director of public relations, American Oil Co., has been elected chairman of the Advisory Committee on Public Relations, Committee on Public Affairs, API. Elected vice chairman was **Don Sweeney,** manager of public relations, Socony Mobil Oil Co. Patterson joined the Public Relations Department of Standard Oil Co. (Ind.) in 1946. He attained his present post with Amoco in 1958. Sweeney joined

Not since 1923

when an early patent was granted covering a valve type tray—has there been any significant change or improvement in this type of tray, other than physical shape and dimensions . . .



Glitsch V-1 Ballast Unit

UNTIL THE DEVELOPMENT OF THE *Glitsch* BALLAST TRAY

. . . a two-stage vapor discharge unit that is:

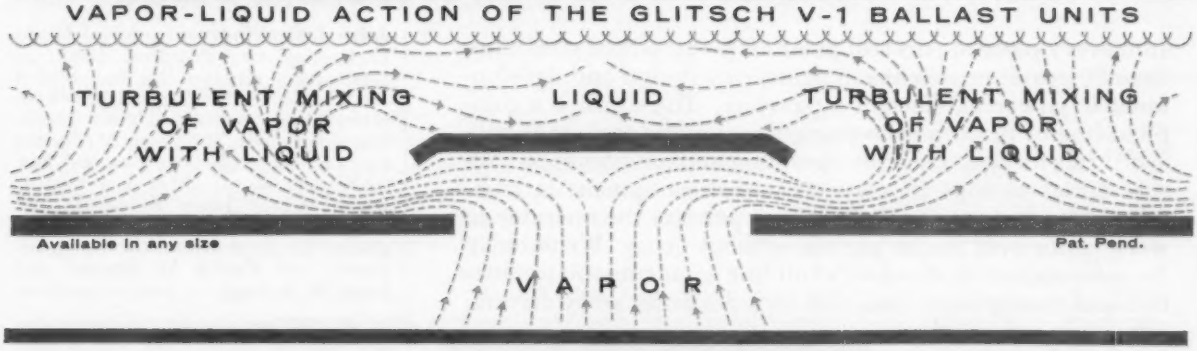
- ★ Low in cost
- ★ Low in maintenance
- ★ High in capacity
- ★ High in efficiency
- ★ High in turndown ratio

The Glitsch V-1 Ballast Unit has a single moving element with a two-stage action. The valve element positions itself initially for low to medium vapor rates and is then free to travel vertically to provide an increased orifice for very high vapor rates.

The high efficiency obtained by the Glitsch V-1 Ballast Tray is a result of the centripetal "fantail" mixing of the vapor and liquid. The vapor discharge orifice of the element is so shaped that the vena contracta at the vapor-liquid interface is amplified by the centripetal force of the vapor, resulting in extreme turbulence, greater interfacial area, and more thorough mixing of the vapor with the liquid.

For additional information on the V-1 Ballast Tray, ask your Glitsch representative for Bulletin #160. Offices in principal cities.

VAPOR-LIQUID ACTION OF THE GLITSCH V-1 BALLAST UNITS



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Glitsch SINGLE ENGINEERING RESPONSIBILITY

Manufacturers of Superior Fractionating Trays Since 1937

For more data on advertised products, use Readers' Service Cards, last page.

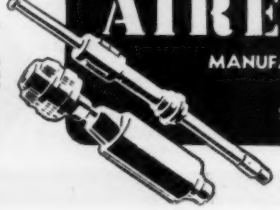
AIR POWER

means efficiency, speed and economy with AIRETOOL PRODUCTION and MAINTENANCE EQUIPMENT

AIRETROL Tube Expansion Control for fast, precision tube rolling. Rugged air-motor drive speeds operation and an automatic torque sensing control stops expansion within .001 inch of predetermined setting. Lightweight and easy to handle. Permits one man to roll 12 tubes a minute.

MODEL CC-475 heat exchanger and condenser tube cleaner. Weighs just 11 pounds for easy one-man operation without supporting rig. Air-motor driven to deliver all the power needed for cleaning clogged tubes up to 1 inch in diameter. Built-in flushing system keeps drill head cool and tubes clear.

Into every piece of Airetool pneumatic equipment goes more than 30 years' experience in pioneering design and development of powerful, efficient air-motors. The result is a complete line of performance-proven pneumatic tools that help speed fabrication, assembly operation and maintenance with substantial savings in costs. Airetool equipment is engineered for fast, easy handling that permits the operator to work faster over longer periods without tiring. Write today for information on Airetool's full line of pneumatic production and maintenance tools that includes drills, screwdrivers, nutsetters and grinders.



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CANADIAN PLANT: 37 Spalding Drive, Brantford, Ontario
EUROPEAN PLANT: Vlaardingen, The Netherlands

Men . . .

General Petroleum Corp. in 1948 as public relations representative and in 1955 went with the Western Oil and Gas Association as manager, public relations. He joined Socony Mobil in 1957, and was named to his present post last year.

William G. Copeland has been named vice president in charge of the Domestic Refining Department, Texaco, Inc. Formerly general manager of the department, he succeeds **Frederic H. Holmes,** who has retired. **Henry Flynn,** manager of Texaco's refinery at Port Arthur, Texas, succeeds Copeland as general manager, Refining Department. Copeland graduated from The Rice Institute with a B.S. degree in chemical engineering. He has been assistant superintendent, Lawrenceville, Ill., works, and superintendent, Sunburst, Mont., and Westville, N.J., refineries. He became general superintendent, Port Arthur works in 1954, and operations manager, New York, in 1956. He was appointed general manager in January 1957.

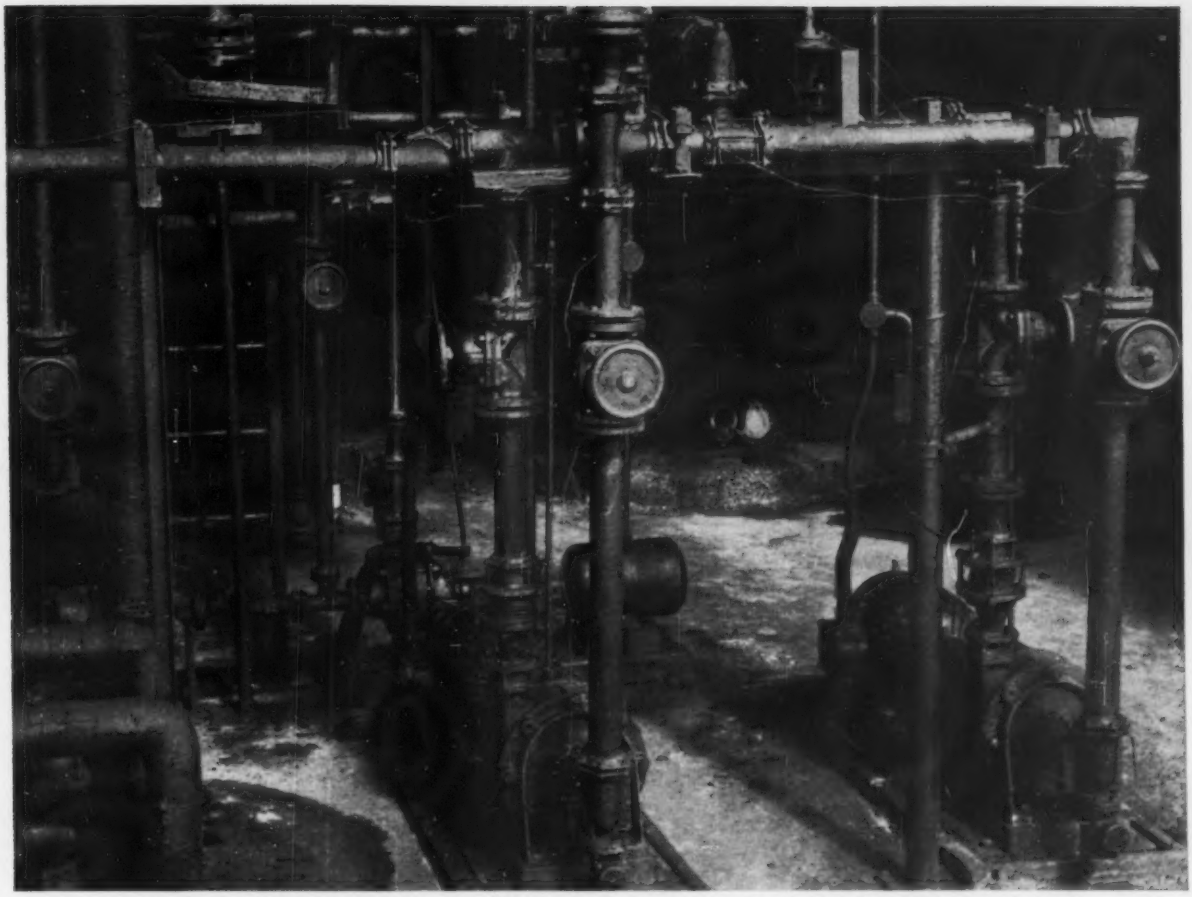
Copeland

Dr. Philip H. Moss has been named manager of the Research Division, Austin, Texas, laboratories of Jefferson Chemical Co. **Dr. Myrl Lichtenwalter** will head the Development Division, and **Robert S. Reese** the Technical Services Division. Dr. Moss has a Ph.D. degree from Stanford University, Dr. Lichtenwalter has a Ph.D. degree from Iowa State College, and Reese has an A.B. degree in chemistry from Western Maryland College.

John J. Harrington has joined Jacobs Engineering Co., Pasadena, Calif., as construction manager. He has headed construction of chemical and petroleum plants throughout the United States, having been with The Ralph M. Parsons Co. The M. W. Kellogg Co., and Foster-Wheeler Corp. Other new men at Jacobs include **James K. Brooks** and **Norman W. Coulson,** senior project engineers; **G. Bruce Lyons,** purchasing engineer; and **Patrick M. Sanford** and **Roger W. Kellogg,** mechanical designers.

J. W. Miller, executive representative of Union Oil Co. of Calif., has retired. He joined Union Oil in 1936 at San Francisco. After serving as assistant to the division manager there, he became division manager, Los Angeles, and later manager, Southwest Territory. He then became executive vice president of Brea Chemicals Co.

Dr. Paul M. Pitts has been appointed research manager, The Atlantic Refining Co.'s Research and Development Depart-



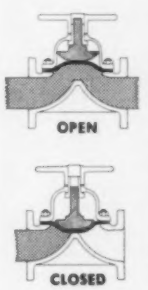
Glass-lined Grinnell-Saunders Valves, with Teflon Diaphragms, on benzene hexachloride lines at Diamond Alkali's Greens Bayou, Texas, plant. Hundreds of other Grinnell Diaphragm Valves are used in other areas of the plant.

How a manufacturer of benzene hexachloride solved a serious valve leakage problem

Valving at Diamond Alkali's Greens Bayou, Texas, plant had become expensive. Leakage of a product containing 30% to 40% benzene and free chlorine released fumes and caused rapid corrosion of the metal parts of the valves used previously, as well as of adjacent equipment.

This problem was corrected when Grinnell-Saunders Diaphragm Valves were used. The first replacement of any part of the Grinnell Valves did not occur for two years, and this was the diaphragm *only*. The former valves had to be *completely* replaced every one to two months! Bodies of the Grinnell valves lasted four years. In short, when Grinnell-Saunders Diaphragm Valves were installed, stem leaks ceased; corrosion was eliminated; and downtime to install new valves was practically ended.

For further facts about Grinnell-Saunders Valves, see Grinnell's insert in Chemical Engineering Catalog, or Sweet's Plant Engineering File — or write directly to Grinnell Company, Providence 1, Rhode Island.

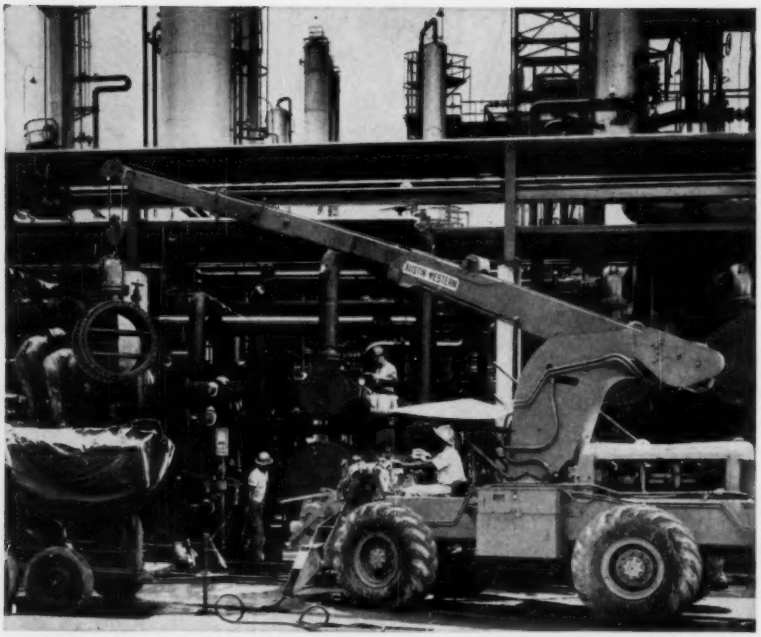


- Diaphragm lifts high for streamline flow in either direction
- Diaphragm presses tightly to effect positive closure
- No packing glands to need attention
- Diaphragm easily replaced without removing valve body from the line
- Wide choice of body, lining and diaphragm materials

GRINNELL-SAUNDERS DIAPHRAGM VALVES

GRINNELL COMPANY, PROVIDENCE 1, R. I. • BRANCH WAREHOUSES AND DISTRIBUTORS FROM COAST TO COAST
PIPE FITTINGS • VALVES • PIPE HANGERS • PREFABRICATED PIPING • UNIT HEATERS • PIPING SPECIALTIES

For more data on advertised products, use Readers' Service Cards, last page.



A-W Model 210 hydraulic crane maneuvers through maze of overhead obstructions in tight quarters to replace channel head on exchanger at Conoco refinery.

HOW A-W HYDRAULIC CRANE SAVES TIME AND MONEY

An efficiency expert recommended to Continental Oil Company that it buy an Austin-Western hydraulic crane on the basis of ability to pull, carry and set exchangers, besides serving for general maintenance and repair. And the company did.

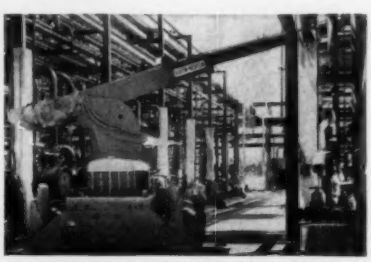
Never idle

Transportation foreman Joseph Carnahan at Conoco's West Lake, La., refinery says, "I don't see how my department ever did without the A-W. It does so many things so fast and safely that it's in constant demand throughout the refinery. Its maneuverability is invaluable in tight spots. The retractable boom lets you lift loads up and carry them through rows of overhead piping; depress the boom and you can travel beneath structures which prohibit passage of ordinary cranes.

"Our Model 210 is 4 years old now and it has never been idle a single day. Operation and maintenance continue to be low while its efficiency and performance remain high. It's a real time and money saver!"

5 models now available

Learn how A-W hydraulic cranes with all-wheel drive and steer can save time and money in your operations. Choose from five models in capacity ranges from 5 to 11 tons. Ask your nearest A-W distributor for full details and demonstration.



Telescoping hydraulic boom with continuous full circle rotation reaches up and over, out and in. Standard on models 210, 210-P, 220 and 410.

Austin-Western

CONSTRUCTION EQUIPMENT DIVISION, AURORA, ILL.

BALDWIN · LIMA · HAMILTON

Power graders • Motor sweepers • Road rollers • Hydraulic cranes

Men . . .

ment. He will direct basic research, application research, and development activities. **W. A. Myers,** acting general manager of the department, will continue direct supervision of research services and crude oil production research. Dr. Pitts joined Atlantic in 1949 after receiving his Ph.D. degree in chemistry from the University of North Carolina.

Joseph W. Meehan has joined Vickers Refining Co., new division of Vickers Petroleum Co., as president. He will also be a vice president and board member of Vickers Petroleum. Appointed president of The Derby Refining Co. last year, Meehan joined Colorado Oil and Gas Co. in 1957 as vice president of Derby Refining in charge of transportation and crude oil purchasing. For 25 years he was with Pure Oil Co., Chicago. Before joining Derby, Meehan was general manager of Pure's Crude Oil Purchasing Division and president of The Pure Transportation Co. and Arapahoe Pipe Line Co.

Meehan

Dr. H. Dayton Wilde has been appointed university relations counselor for Humble Oil & Refining Co. Formerly research coordinator, Humble Division, he will guide relations with colleges and universities from which Humble recruits many new employes. Dr. Wilde attended The University of Texas, where he received a B.S. degree in chemical engineering in 1923 and a M.S. degree in 1924. He holds a Sc.D. degree from MIT.

W. D. Seyfried has been appointed manager of research for Humble Oil & Refining Co. Formerly head of the Baytown refinery's Research and Development Division, he will coordinate all scientific research carried out by Humble. He will also advise the board in regard to available research programs, formulate and recommend research policies and plans, and evaluate research results.

George L. Mateer has been elected president and general manager, Cities Service Refining Corp., succeeding **Louis D. Mann,** who is retiring. Mateer has been vice president, director and assistant general manager of the company since 1955. He has been with Cities Service in refining and manufacturing activities since 1943, prior to which he was with Standard Oil Co. (N.J.).

Joe C. Dickson has joined Bonner & Moore Engineering Associates, Houston. He was previously with Humble Oil & Refining Co. where he worked in lubes processing and crude distillation, doing

For more data on advertised products, use Readers' Service Cards, last page.

Jefferson Gas Processing Specialist makes a house call on ailing refinery

Your refinery engineers have already diagnosed your gas sweetening ailment . . . contaminants that are causing either corrosion, neutralization of solution, foaming, or a combination of detrimental results. Pinpointing the cause and cure remains. Here, Jefferson Chemical's Gas Processing Specialist can help.

He is no Merlin. His procedure is to sift and evaluate all pertinent data with your engineers. He will review such factors as the composition of the gas to be treated, the percentage of hydrogen sulfide and/or carbon dioxide in the gas and final purity desired; your choice of amines and solution strength; solution circulation rate which depends on quantity, temperature and pressure of the gas treated; operating conditions for absorption and reactivation. Often your problem, with specimen solutions, is referred to Jefferson's Austin Research Laboratories for analysis and study. This coordinated probing, plus Jefferson's vast fund of case experiences, will help you arrive at the best remedial action to minimize costly corrosion and solution contamination.

When you have a knotty gas sweetening problem, call in the Jefferson Gas Processing Specialist. He can provide prompt technical services plus ethanolamines in the quantity and purity you need . . . Jefferson Chemical Company, Inc., 1121 Walker Avenue, P. O. Box 303, Houston 1, Texas.

Ethylene and Propylene Oxides, Glycols, Dichlorides, Carbonates
SURFONIC® Surface-Active Agents • Ethanolamines • Morpholine
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Unlimited Flexibility!

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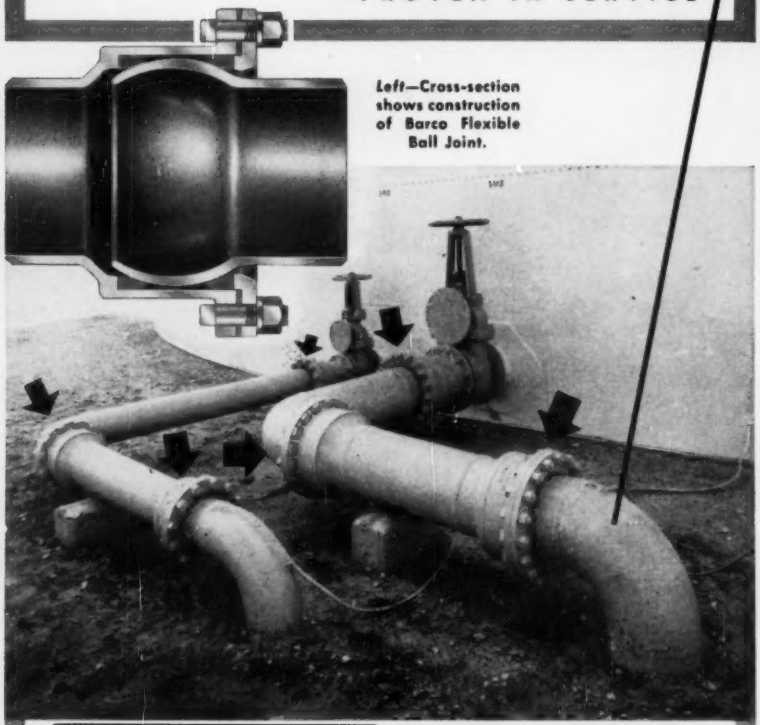
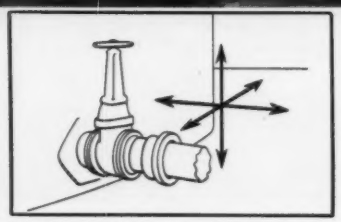


Left—Cross-section shows construction of Barco Flexible Ball Joint.



Allows 6-Way Movement!

Freedom of movement in any direction is readily possible with these *ball joint connections* of 12" pipe (right) and 8" pipe (left) to 80,203 bbl. tank shown in above photo. (Photo: SHELL OIL COMPANY, Dominguez Refinery, Wilmington, Calif.)

Barco Ball Joints—*Fire Safe!*

provide complete protection against FIRE, PIPE EXPANSION, TANK SETTLING

Major oil companies throughout the country now approve the use of Barco's new large size Flexible Ball Joints on tank connections for the following reasons:

1. **Fire-safe. The joints have passed rigid fire and water spray tests.**
2. **Superior for handling pipe expansion—no combustible packing, no thin wall sections, no "end thrust" from pressure, no heavy pipe anchoring required.**
3. **Complete protection—relieve strain and twisting forces on valve flanges or tank wall.**
4. **Compact! Ideal for use inside narrow space between fire wall and tank. Easy to design piping for any amount of flexibility desired.**
5. **Also useful for insulating piping against electrolysis.**
6. **Long service life without maintenance. No lubrication. Sizes to 16"; flanged or welding ends.**

For engineering recommendations, see your nearest Barco representative or write. ASK FOR CATALOG 215B and BULLETIN 31-A.

PRODUCTS BACKED BY EXPERIENCE BARCO FOUNDED 1908

BARCO MANUFACTURING CO.

542E Hough Street • Barrington, Illinois

The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Revolving Joints

In Canada: The Holden Co., Ltd., Montreal

Men . . .

process design and process control problems. Later, he worked in applied statistics, economic analysis, and computer applications to technical and engineering problems.

Dr. Ernest W. Thiele has retired from Standard Oil Co. (Ind.). Development coordinator at Standard's Whiting research laboratories, he joined the company in 1925 after receiving a Ph.D. degree in chemical engineering from MIT. While still at MIT, he developed with **Dr. Warren L. McCabe,** the McCabe-Thiele method for calculating distillation problems. At Standard, he has been assistant director and associate director of research.

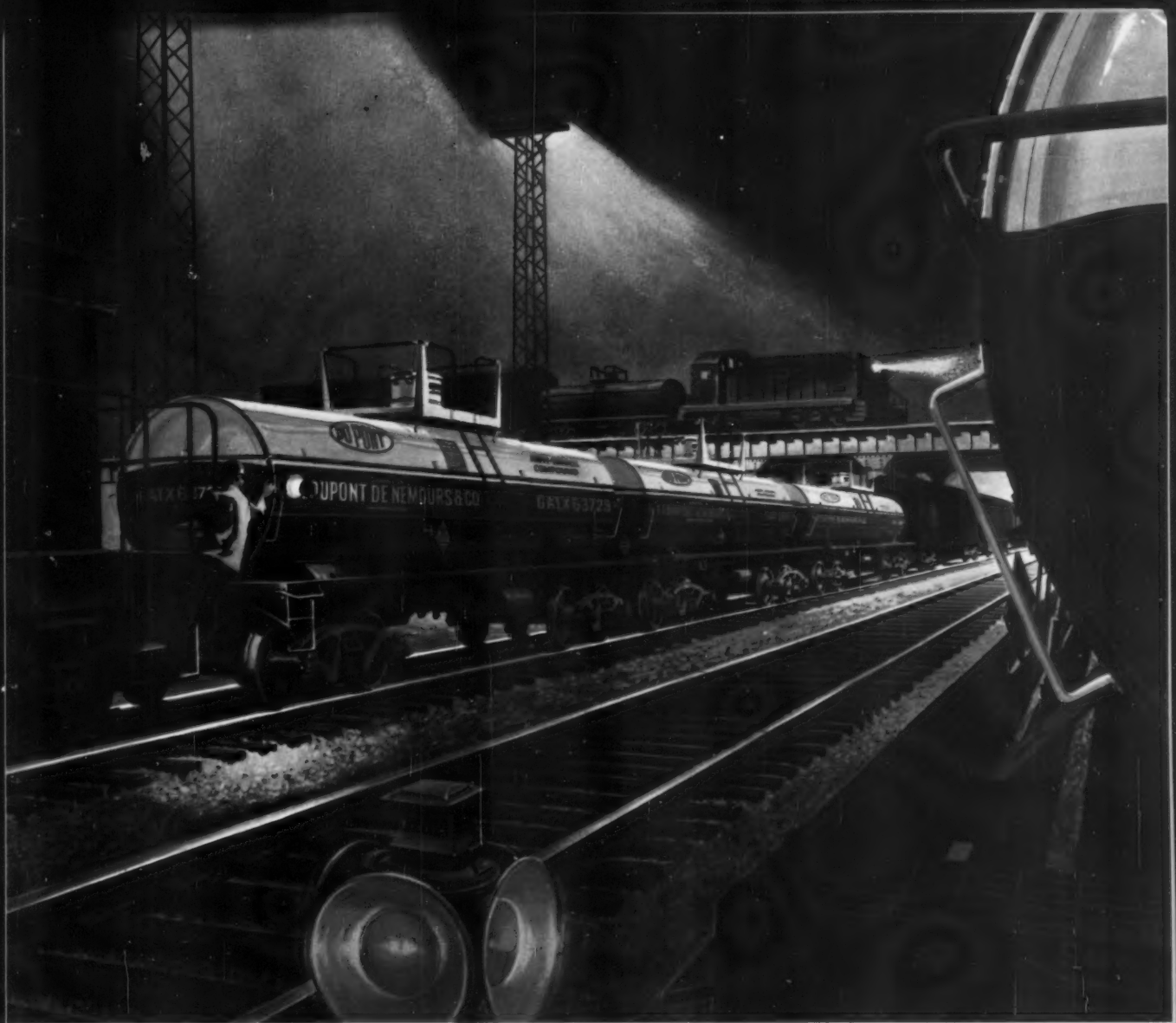
Dr. D. R. Frey has been named general manager of the Product Development and Quality Control Department, Kerr-McGee Oil Industries, Inc. Others assigned to the new department are: **L. W. Okon,** manager of sales technical services; **F. C. Champlin,** chief chemist; and **H. L. Norlin,** laboratory supervisor. The new department will act as liaison between marketing and manufacturing in the development of new products and changes of existing products.

W. L. Martin has been promoted to staff engineer, and **H. A. Ward, Jr.,** to senior mechanical engineer, Technical Division, Humble Oil & Refining Co.'s Baytown, Texas, refinery. Martin is currently serving on a rotational assignment as product coordinator for the refinery's new polyolefin unit. Ward handles problems related to the development, design and maintenance of control systems in process equipment.

Harry M. Howarth, senior staff engineer in the General Engineering Department, Standard Oil Co. (Ind.), has been appointed chairman of the code for pressure piping, petroleum refinery piping. His section is under the direction of Sectional Committee B31, ASA, and is under administrative sponsorship of ASME. Howarth is a chemical engineering graduate of Iowa State College.

William H. Thorbecke has been named assistant manager, Petroleum Chemicals Division, Mobil International Oil Co. He was formerly manager, International Division, and managing director of the overseas subsidiary of Continental Carbon Co. Before this, Thorbecke was in petroleum chemical market development activities in Europe and Japan.

Eli Perry has been given a one-year assignment with Monsanto Chemical Co.'s research laboratories, Zurich, Switzerland. To leave immediately for Europe, he will be with Monsanto Research, S. A., doing exploratory research work of his own selection. Since 1957, Perry has been a research associate in the Plastics Division's Research Department.



Convenient 'round-the-clock delivery service for Du Pont tetraethyl lead customers

No matter what time of day or night your order for a tank car shipment of tetraethyl lead reaches us, there is a car already loaded and waiting on a rail siding not far from your refinery.

We call this 'round-the-clock delivery system our "warehouse on wheels." It's a ready-made assist for your emergency TEL needs, enabling you to meet additional production requirements on short notice.

And it also acts as a backstop for our regularly scheduled TEL delivery program—minimizing the danger of a shutdown due to a delivery delay caused by unforeseen circumstances.

In addition to our three plant locations there are 25 special rail sidings located near the major refining areas to take care of all possible refinery needs.

Assurance of fast and reliable delivery service, either for TEL or other petroleum additives, is just one of the advantages of doing business with Du Pont.

For the many other services available, contact your Du Pont representative or write to E. I. du Pont de Nemours & Co. (Inc.), Petroleum Chemicals Division, Wilmington 98, Delaware.

DU PONT
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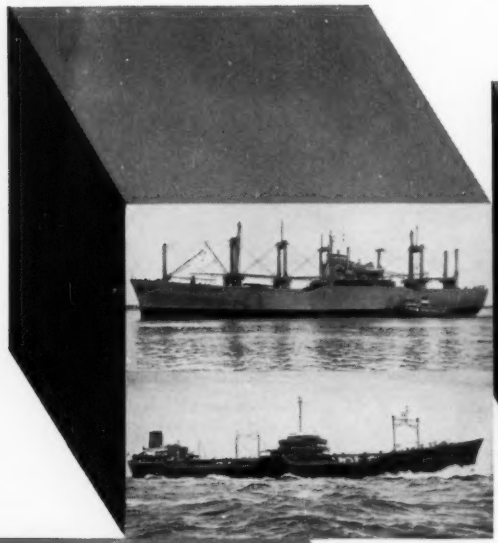
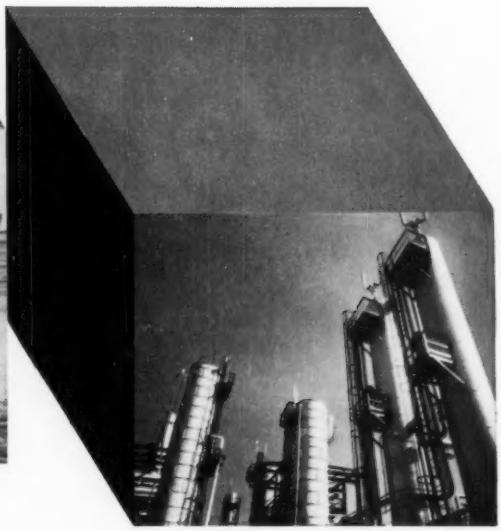
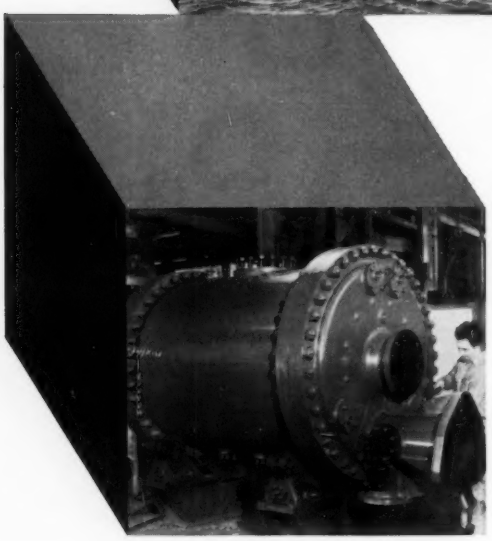
Better Things for Better Living
. . . through Chemistry

Tetraethyl Lead
and other
Petroleum Additives







SUN SHIP built 'em all....

Our reputation as "master builders for land and sea" is based on 44 years' service to the oil-refining, chemical and other industries.

Frequently we are called upon to produce components for the building of large plants. Our manufacturing and fabricating skills, our understanding of industry's problems are reflected in the variety of equipment we build, like the fractionating towers and special pressure vessel shown here.

In our complete, modern shops we build and *deliver* what's needed in many fields. Our special Alloy Products Shop, for example, is equipped to produce medium and heavy stainless alloy and aluminum products for industry.

Building for land • Pressure vessels • Fractionating towers • Stills and tanks • Condensers and similar equipment • Special machinery • Plate work, etc.

Building for sea • Dry cargo ships • Tankers • Marine repairs • Dredges • Ferries • Marine engines • Marine machinery.

Sun Ship does a big job for many companies, and can do the same for you.

Sun

SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE • SINCE 1916 • CHESTER, PA.

Men . . .

A. C. Rubel retires this month as president of Union Oil Co. of Calif. He will continue with the company as a director and member of the Executive Committee. Rubel was awarded the AIME Antony Lucas medal on February 17 for his contributions to the oil industry.

G. M. Rowell has resigned from Kellogg International Corp. to become chief process engineer for a new consulting engineering firm, Etude et Realisation de Projets Industriels (ERPI), Paris, France. The firm offers industrial development and consulting services to the petroleum, petrochemical and chemical industry.

Dr. Adalbert Farkas has been named assistant director of research at Houdry Process Corp., Philadelphia. With the company since 1956, he previously headed the Organic Research Section. Before joining Houdry, he was with Union Oil Co. of Calif. and Barrett Division, Allied Chemical Corp.

John T. Oxley, former president of Texas Natural Gasoline Co., has been named executive vice president of Union Texas Natural Gasoline Co. Named senior vice presidents were **Frank B. Markle, Wayne V. Jones, Daniel B. Lovejoy** and **R. C. Frederick.**

James L. Rumsey has joined Delhi-Taylor Oil Corp., Dallas, as administrative assistant in the Executive Division. Before joining Delhi, Rumsey was associate analyst in the Coordinating and Planning Department, Continental Oil Co., Houston.

Claude Wild, Jr., has been named a Washington, D. C., legislative representative for Gulf Oil Corp. A business administration and law graduate of The University of Texas, he has been a counsel for the Mid-Continent Oil and Gas Association, Washington, D. C.

Davis E. Day has been named president and chief executive officer of Witfield Chemical Corp., recently formed by Richfield Oil Corp. and Witco Chemical Co. **Max A. Manning,** Witco president, has been named executive vice president.

James A. Wilson has been named an engineering associate by Esso Research and Engineering Co. He does electronics and instrument development work in the Mechanical Division. He has been with the company since 1937.

Arthur W. Mohr has retired as president of California Spray-Chemical Corp., subsidiary of Standard Oil Co. of Calif. He also leaves the post of vice president of California Chemical Co., Standard's prinicpal chemical subsidiary.

Charles Lurie has been named a research chemist for The M. W. Kellogg Co.'s Research and Development Labora-

HAGATREAT

A **NEW** TREATMENT THAT SIMPLIFIES CORROSION CONTROL IN COOLING WATER SYSTEMS

NEW . . . Hagatreat not only controls corrosion, but also provides freedom from sludge or scale.

NEW . . . Hagatreat usually permits make-up water to be concentrated more in the cooling tower system, which means savings in both chemicals and water. Disinfecting is less difficult, too.

NEW . . . Several years of testing indicate Hagatreat will reduce steel corrosion to 1 or 2 mils per year; copper to less than a few tenths of a mil per year. No pitting tendency.

NEW . . . Hagatreat is easy to handle, may be fed in solutions containing up to one pound per gallon. Call on Calgon Company's technical service for complete information on Hagatreat and other cooling water treatment products.

A Calgon engineer will be glad to discuss your particular problems and prescribe both treatment and treatment routine. Write or phone:

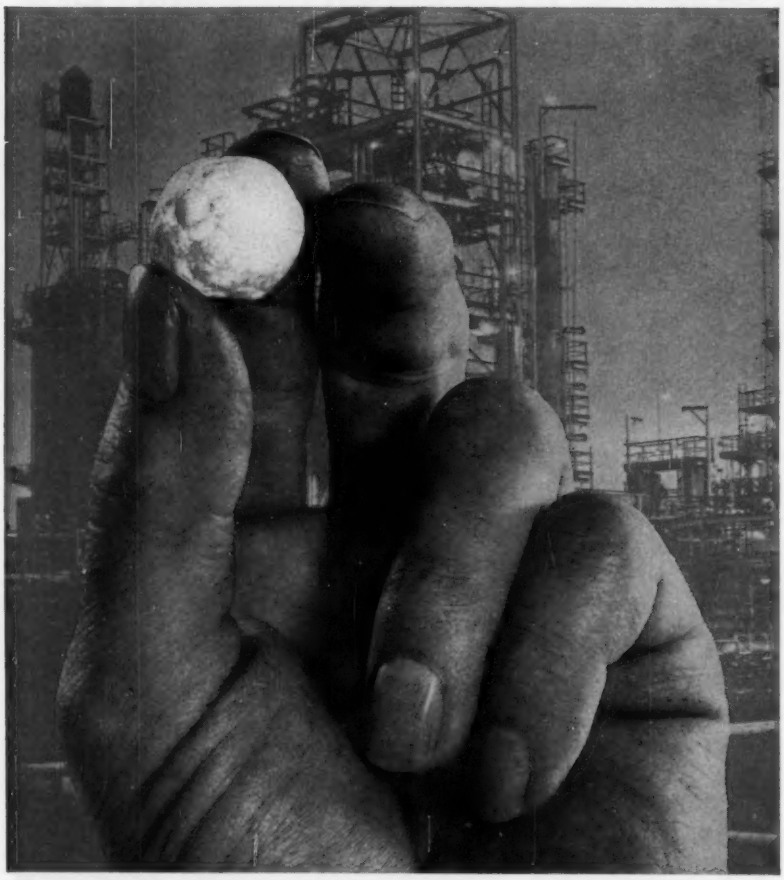
CALGON COMPANY
HAGAN BUILDING, PITTSBURGH 30, PA.

DIVISION OF **HAGAN** CHEMICALS & CONTROLS, INC.

For more data on advertised products, use Readers' Service Cards, last page.

FOR CATALYST BED SUPPORT:

This Porter Mullite Pellet costs up to 50 per cent less!



Porter Mullite Pellets actually do cost up to 50 per cent less than most catalyst bed support materials now available. *And you make no operational sacrifice to gain this savings!*

Porter mullite pellets have been commercially tested for over three years, as inert support for active catalyst, in many major refineries. They've withstood all the trials of heat, shock and pressure without breaking or dusting. Porter mullite pellets have successfully resisted abrasion, erosion and crushing . . . completely protecting the valuable catalysts from contamination.

Convert to Porter mullite pellets now, and reflect these important cost-savings in your refining process. For complete information, write: *Refractories Division, H. K. Porter Company, Inc., Porter Building, Pittsburgh 19, Pennsylvania.*

REFRACTORIES PORTER DIVISION

H.K. PORTER COMPANY, INC.

PORTER SERVES INDUSTRY: with Rubber and Friction Products—THERMOID DIVISION; Electrical Equipment—DELTA-STAR ELECTRIC DIVISION, NATIONAL ELECTRIC DIVISION, PEERLESS ELECTRIC DIVISION; Specialty Alloys—RIVERSIDE-ALLOY METAL DIVISION; Refractories—REFRACTORIES DIVISION; Electric Furnace Steel—CONNORS STEEL DIVISION, VULCAN-KIDD STEEL DIVISION; Fabricated Products—DISSTON DIVISION, FORGE AND FITTINGS DIVISION, LESCHEN WIRE ROPE DIVISION, MOULDINGS DIVISION, H. K. PORTER COMPANY de MEXICO, S. A.; and in Canada, Refractories, "Disston" Tools, "Federal" Wires and Cables, "Nepcoduct" Systems—H. K. PORTER COMPANY (CANADA) LTD.

Men . . .

tory, Jersey City, N.J. Holder of a M.S. degree in physical chemistry from Purdue University, he did his undergraduate work in chemistry at Brooklyn College.

Dr. Elliott I. Organick has been named assistant director of the Ford Foundation computer project on the use of computers in engineering education, University of Michigan. On leave from his post as director, computing center, University of Houston, he will serve seven months under **Dr. D. L. Katz,** director of the project.

Dr. Robert Price Russell has been elected a director of Cosden Petroleum Corp. Dr. Russell is consultant for W. R. Grace & Co., president of International Basic Economy Corp. Research Institute, and executive vice president of the American International Association for Economic and Social Development.

Charles H. Sommer has been elected president of Monsanto Chemical Co. and Charles A. Thomas to the board. Sommer had been executive vice president and a board member since June 1959. Thomas had served four years as executive vice president.

F. W. Steckmest, manager of the Employe Communications Department, Shell Oil Co., has been named chairman of the Advisory Committee on Employe Information, API Committee on Public Affairs. He joined Shell Development Co. in 1947, and attained his present position in 1954.

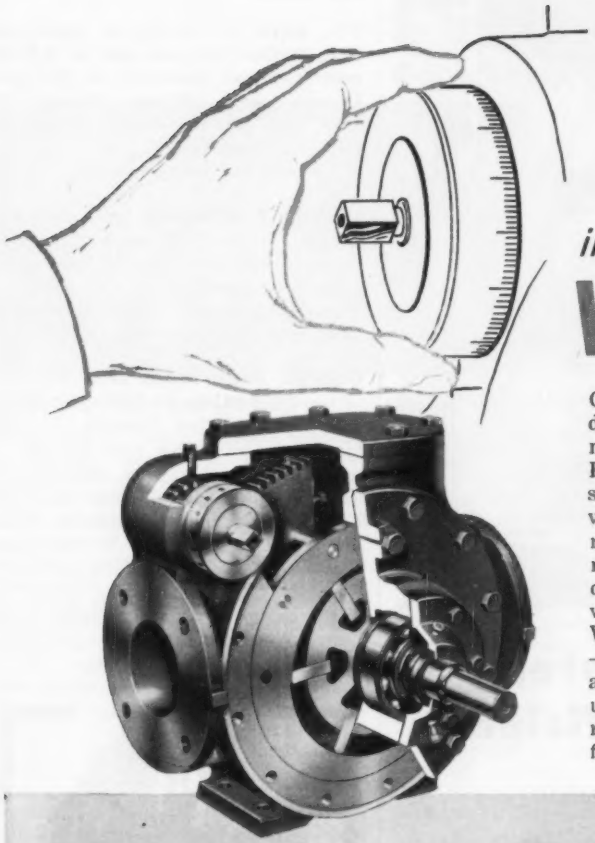
H. D. Moore has been named president of Derby Refining Co., and a director of Colorado Oil and Gas Corp. He was previously vice president and executive assistant for Sinclair Oil Corp., New York, where he held various refining and marketing positions.

Addison W. Hubbard has been appointed research associate in Esso Research and Engineering Co.'s Research Division. With the company 17 years, he specializes in butyl-rubber development. Hubbard graduated from the University of North Carolina, and is a member of ACS.

Harold Bottomly has been named regional manager of Vitro Engineering Co., Treco Division. He will supervise the Tulsa office, with responsibility for engineering, construction and sales.

J. W. Scott has been appointed division supervisor, Petroleum Process Development Division, Richmond Laboratory, California Research Corp. He joined the company in 1946.

Harold R. Horner, Jr., has been appointed Conroe plant manager for Jefferson Chemical Co. He received his



NOW! DIAL ANY FLOW

instantly with new

VARI-FLO PUMPS

One Speed — Any Flow Rate! Just a turn of the dial, and the Vari-Flo delivers exactly what you need . . . as you need it. Essentially, the Vari-Flo is a highly efficient vane-type pump with a simple means for changing its displacement to vary delivery from zero to full capacity while running at constant speed. Without changing rotation, it can even reverse its flow to evacuate discharge lines after shutoff! The need for costly variable-speed drives is completely eliminated. With Vari-Flo, you change pump displacement — never the speed. Truly the most versatile of all pumps, the new Blackmer Vari-Flo offers unique solutions to countless pumping problems requiring quick or accurate control of liquid flow.

VARI-FLO makes proportion easy and economical

The development of the Vari-Flo pump provides a new approach to simplified liquid proportioning. Typical applications for Blackmer proportioners cover a wide range of liquids and processes including the blending of fuel oils, asphalt, gasoline, lube oils, solvents, waxes, chemicals and many others. The low first cost of such an installation, coupled with its ease of installation and maintenance, can effect remarkable savings over the complex equipment that was once required.

FREE CATALOG and ENGINEERING ANALYSIS

For complete information, write for Bulletin 600

"liquid materials handling"® equipment

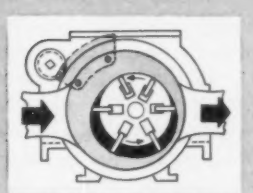
BLACKMER

VARI-FLO PUMPS

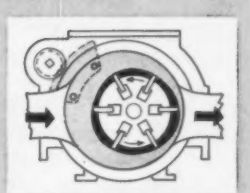
BLACKMER PUMP COMPANY

1809 Century, S.W., Grand Rapids 9, Michigan

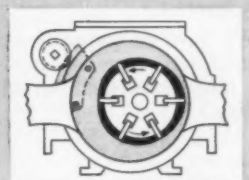
Flow control is simple and positive:



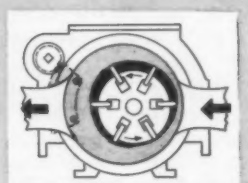
100% FORWARD FLOW. Maximum flow from full-size pumping chamber at bottom. Rotor and movable liner (shaded area) are tangent at top.



PARTIAL FORWARD FLOW. Dial rotates liner to decrease width of pumping chamber, reducing forward flow. Portion of flow is carried back at top.

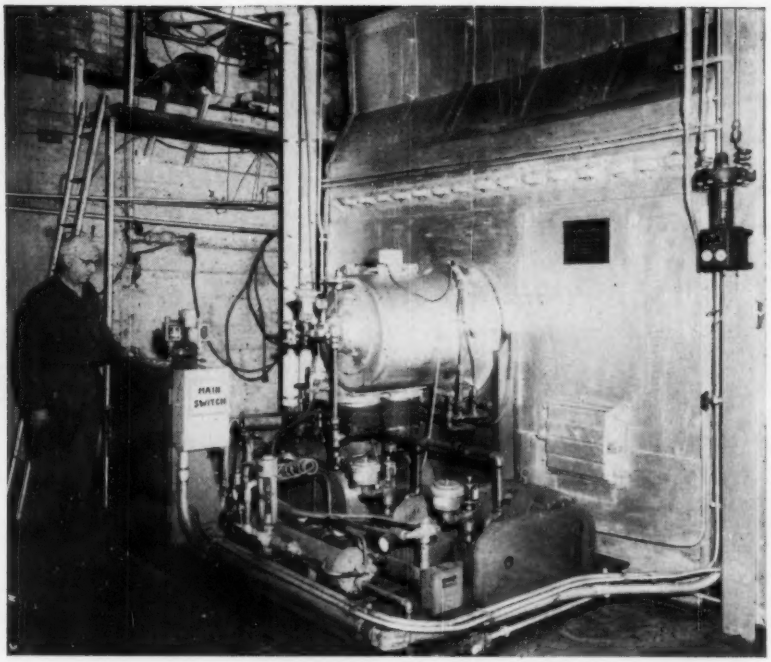


NO FLOW. Liner is rotated to neutral position, equalizing areas above and below rotor. Liquid recirculates inside the pump.



REVERSE FLOW. Liner is further rotated, resulting in more liquid being carried back across the top than forward across the bottom. Flow is reversed without changing pump rotation.

For more data on advertised products, use Readers' Service Cards, last page.



No Fuel Burning System Can Match O & S for Efficiency

Superiority of O&S burner systems can be demonstrated by these facts:

1. **Extraordinary Fuel Savings**—Impressive fuel savings are provided at *all* firing rates. Savings often pay for investment in a matter of months.
2. **Efficiency**—Higher *guaranteed* burner efficiency over a *wider* turndown rate than any other burner system.
3. **Performance**—O&S burner systems outperform all other assemblies. 5 to 1 turndown *without increase in excess air ratio is* widest in industry. Combustion air, accurately controlled, plays *no* part in atomization.
4. **Dependability**—No moving parts exposed to high temperatures. No tiny orifices to clog or distort.
5. **Flexibility**—Complete units for any commercial grade of fuel oil, any commercial gas (including sewer gas.) Air atomizing or steam atomizing.
6. **Typical Results**—A major New York State manufacturer is effecting a labor saving at the rate of $40,000 annually. (Name on request.)

Want more proof? We have an impressive array of case histories and performance data that are eye-openers. You owe it to yourself to investigate this outstanding burner system. Write for Bulletin 1255.

75th Anniversary

ORR & SEMBOWER, INC.

World Leader in Packaged Boilers and Burners

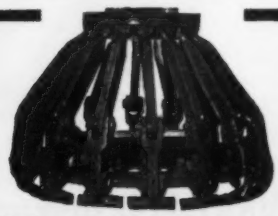
710 Morgantown Road, Reading, Pa. • Since 1885

Men . . .

B.S. degree in chemical engineering from Purdue University and his M.S. degree from the University of Michigan. Horner joined Jefferson Chemical in 1949, and his most recent assignment was as assistant to the general manager of research and development.

William E. Schiesser has been named assistant professor of chemical engineering at Lehigh University. An honor graduate in chemical engineering from Lehigh in 1955, he received his M.S. degree from Princeton University in 1958.

George Armistead, Jr., proprietor of George Armistead and Co., St. Michaels, Maryland, died February 27, 1960. He is survived by his wife and son. A native of Houston, and graduate of Texas A & M College, he was once with The Texas Co. and its subsidiaries, Gasoline Products Co., and Process Management Co. Later affiliations were with Republic Oil Refining Co., where he was in charge of refining operations, and Foster Wheeler Corp. where he was a supervisory chemical engineer.



BARRETT automatic

Filling and Crimping Equipment

for handling greases and other viscous fluids.

- **No operator required.**
- **100% air operated.**

Fills, seals, stamps and counts lug cover pails. Output of 15 pails per minute. Write for details on installation to meet your requirements.

BARRETT

Manufacturing Co.

P. O. Box 8096, Houston 4, Texas

REFRACTORY HAYDITE

Makes Higher Heat Resistant Concrete

Haydite aggregate used with Lumnite cement produces refractory concrete suitable for sustained temperatures up to 1800-2000° F., which makes it excellent for tubular heaters, ducts, flues, stacks and catalytic crackers. Weighing from 30 to 40 per cent less than ordinary aggregate concrete, Haydite is exceedingly strong. It has excellent insulating properties and withstands pressures of up to 1130 pounds per square inch. Write today for free folder and complete information about Carter-Waters Refractory Haydite.

We sell direct to you.

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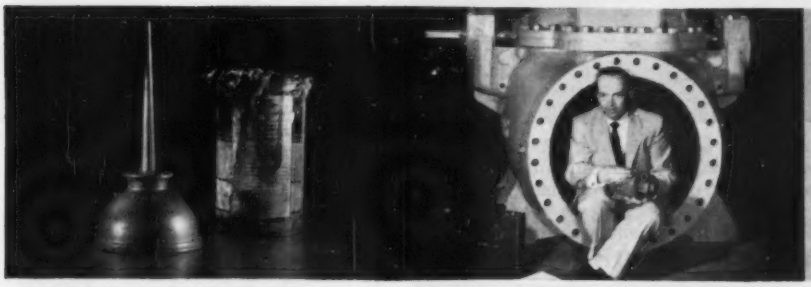
CARTER-WATERS

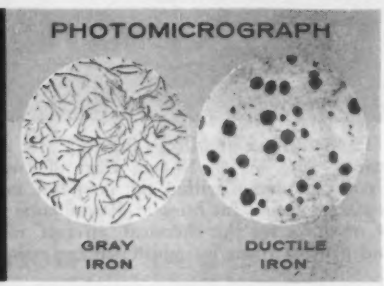
KANSAS CITY MISSOURI

2440 Pennway **Phone GRand 1-2570**

PUMPAGE

Goulds news about pumps for process industries





Lubricate with oil or grease?

If all you're thinking about is lubrication *per se*—oil is better than grease. It's easy to cool, stable, easily replaced. But . . . there are problems. Oil, contaminated by even tiny amounts of moisture, fumes, dust, shortens bearing life. Keeping oil level right for both small and large bearings is difficult. Grease lubrication almost completely solves these problems. It forms a barrier that keeps contaminants from reaching the bearing. It doesn't churn through the bearing, bringing contaminants with it. It *ends* the problem of lubricant level. We feel that grease is a good universal lubricant for pumps and a majority of our new units are available with *either* oil or grease lubrication . . . you have your choice of lubricant to meet the needs of any application.

Centrifugals for cooling towers

You can pump up to 40,000 gpm from your cooling towers with the mammoth Model 3420 centrifugal pump you see here. Or, if you want the same capacity but more flexibility, try a pair of Model 3405's. In either case, you get a pump that's a cinch to work with should you ever want to go inside it. Horizontally split casing comes apart easily when you remove a few bolts. You don't disturb piping, pump, or driver alignment. You look inside, adjust, maintain in a matter of minutes. Both the Model 3405 and the big job (Model 3420) have proved themselves under the severest services. For construction details, ratings and specifications write us for Bulletins 721.6 and 721.8.

The ductile iron difference

To make ductile iron, magnesium is added to molten cast iron, changing the sharp, thin graphite flakes to spheroids. The spheroids have large areas of iron matrix between them, and since they have no sharp edges, the ductile iron has far greater strength than the original cast iron.

Ductile iron is so tough it can be used in many applications previously requiring cast steel.

It might pay you to look into this. Write us for information on ductile iron pumps or parts.

Intermediate range design... new way to handle hot pumpage

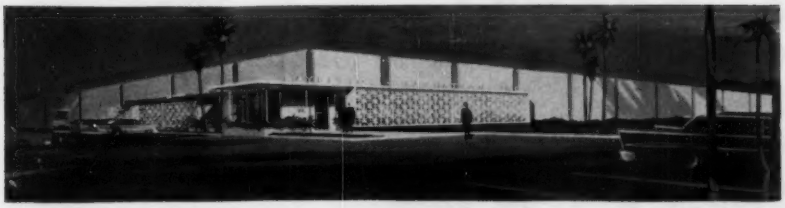
You know how it *used* to be—you bought a light duty pump for temperatures up to 200° and a real heavy duty pump to go from 200° to 800°. Consequently, when you were operating in the intermediate range—that area of temperature between 200° and 650°F—you usually had more pump than you needed. Well, that's changed. Here's a process pump that fits into the intermediate range like a glove. It handles all light duty applications and the growing number of intermediate applications as well. Yet it costs very little more than a light duty pump with built-in temperature limitations. For complete application data, drop us a line asking for our bulletin on the Model 3775.

Points on a close-coupled process pump

Here's a brief bulletin—but one loaded with facts—on the Model 3675 close-coupled process pump. It gives you complete specifications on this compact, economical pump which we built expressly for the petroleum industry. It contains full construction details, dimensions, and a handy pressure-temperature chart. For your free copy, just drop us a line. Goulds Pumps, Inc., Dept. PR-40, Seneca Falls, N. Y.

GOULDS PUMPS

Suppliers Notes...



Pictured is an architect's drawing of a new plant being erected by Raybestos-Manhattan, Inc., on an 18-acre tract of land recently purchased in Fullerton, Calif. Upon completion within the next few months, the new, air-conditioned plant will replace existing facilities at Paramount, Calif. It will specialize in the production of products for the chemical, aircraft, missile and rocket, and electronic industries and provide room for additional expansion.

L. Sonneborn Sons, Inc., has changed its name to Sonneborn Chemical and Refining Corp. In conjunction with the name change, the firm has a new company-developed symbol which will be incorporated into all printed sales and corporate material. The photo shows a group of Sonneborn vice presidents discussing the company's new logotype and symbol. In the group (L to R) are Gustave Schindler, Dr. Henry Sonneborn III, Rudolph Cubicciotti and Dr. Erich Meyer.

Sales personnel from six regional offices of Daniel Orifice Fitting Co. met recently at the home office and plant in Houston for a two-day session on sales policies and goals. The meeting was conducted in a new research laboratory the company has erected on its plant site. Highlights of the meeting were discussions of several new products the company plans to market in 1960, plus expansion plans already under way. Sales representatives came from offices in Los Angeles, Odessa, Dallas and Corpus Christi, Texas; Tulsa, and Harvey, La., as well as from Houston. The photograph here shows the group posed in front of the main office.

SELAS CORP. OF AMERICA has named **William J. Bergeron** sales representative, Houston District. He will represent the firm's Micro-Processing Division throughout Oklahoma, Louisiana and Texas, in the sales of equipment for the removal of solid, liquid or vapor contaminants from fluid systems. His sales activities will also include generation and purification equipment for producing high purity hydrogen. Bergeron joined Selas from Sterling Packing and Gasket Co., Houston, where he had been a sales engineer.

ENJAY CO.'s Butyl Division has named **Jack Arnold, Jr.,** marketing coordinator. Since December 1957 he had been manager of the Boston office, where he was responsible for the New England area. He joined Enjay in June 1955, serving for a year and a half as a sales representative in New England. From 1948-55, he was with an affiliated company's New Jersey Division as an industrial salesman. Arnold will be responsible for coordinating marketing activities for Enjay butyl rubber. He will be headquartered in New York.

GENERAL MILLS CORP. has appointed **Malcolm C. Graham** New York sales representative for the Chemical Division. Before joining General Mills, he was with American Cyanamid Co. in purchasing and sales. A graduate of the University of Alabama with a degree in chemistry, Graham will be responsible for the sale of polyamide resins, liquid co-reactants, fatty nitrogen chemicals, epoxy resins, and other organic specialty chemical products.

THE BABCOCK & WILCOX CO. will establish a Boiler Division district sales office in Denver. The new facility has taken over steam generating equipment sales and service activities which were relinquished by The Stearns-Roger Manufacturing Co. on termination of its sales agency agreement with the division March 1. Appointed Denver District sales manager is **Robert L. Swinney,** sales engineer in Chicago for the past 21 years.

AMERICAN POTASH & CHEMICAL CORP. has named **Dr. Howard E. Kremers** district manager of market development. He previously was manager of market development for the company's Lindsay Division. Kremers will be responsible for all corporate market development activities assigned to the Eastern District, with headquarters in the Eastern general sales office, New York.

KAISER REFRACTORIES & CHEMICALS DIVISION has changed the names of three of its sales subsidiaries to that of the parent organization, Kaiser Aluminum & Chemical Corp. The Mexico Refractories Co. of Ohio, will operate under the name of Kaiser Refractories & Chemicals. **Robert Artman** and **Will Combs** will continue as district sales managers re-

BARBER COLMAN

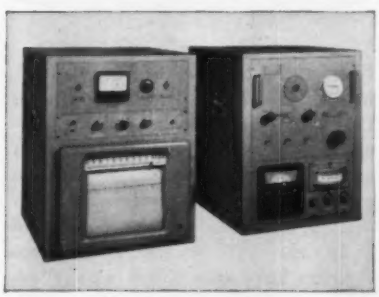
THE BARBER-COLMAN *Analyzer*

Wheelco Instruments Division

THE CHROMATOGRAM IS THE PROOF

WHEELCO MODEL 10

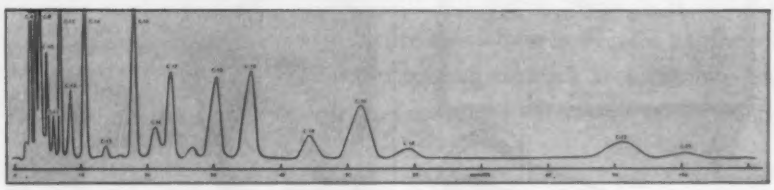
Single or dual operation with packed or capillary columns. Individual temperature control for sample injection, column, and detector. Electronic integrator and automatic readout for fast, accurate reading, optional.



WHEELCO MODEL 20

Compact, portable unit for laboratory and industrial use. Designed to accept capillary or coiled packed columns. Individual temperature controls. Integrator and automatic readout, optional.

Look for difficult separations and completely resolved peaks



For top efficiency, accuracy and reliability, a chromatograph must be able to make difficult separations and complete resolution of peaks. The above chromatogram is typical of the efficiency of Barber-Colman Gas Chromatography. This chromatogram shows complete separations of methyl esters of fatty acids using an eight foot column packed with succinate polyester of ethylene glycol. Column temperature was 170°C and chart speed was 6 minutes per 10 inches. Other chromatograms from many types of runs are in our files awaiting your study. These chromatograms are proof of the accuracy and reliability of Barber-Colman Gas Chromatographs. As the first American manufacturer of ionization detection systems, continuing research and development at Barber-Colman has set standards for America's industrial and laboratory requirements for gas chromatography. New techniques and accessory items developed by Barber-Colman have already done much to further the art of chromatography. One of these, for example, is a new tritium detector. This detector gives even less baseline noise than strontium — 90; i. e. one-tenth that of radium. This, of course, provides greater sensitivity. Other Barber-Colman items that increase the versatility of the instrument are a flame detector (as an accessory), separate temperature controls for the column heater, flash heater and detector, plus adjustable sample splitter, effluent splitter, automatic or manual attenuation, events marker and automatic readout. Why not write for complete information?

Application Flexibility

Barber-Colman Chromatographs permit accurate recording and full-range control over all phases of operation. The components and assemblies are readily accessible to provide the flexibility necessary for maximum range of applications. For instance, the ionization detector is available with many combinations of radioactive sources, anodes and insulators to suit a wide range of analytical requirements. One user reports that with his Barber-Colman Model 20 equipped with an ionization detector he has been able to detect trace components in concentrations of one part per billion or less. Superiority of this type makes Barber-Colman probably the most flexible chromatograph commercially available.

Nationwide Network of Sales and Service Representatives

Investigate the features that are significant to your chromatography requirements by calling the nearest Barber-Colman sales and service office.

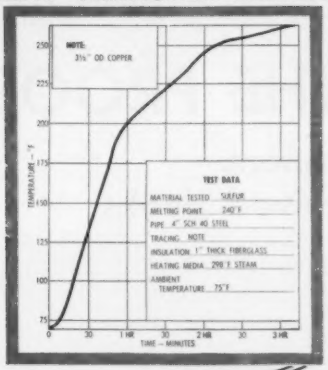
Wheelco Instruments Division

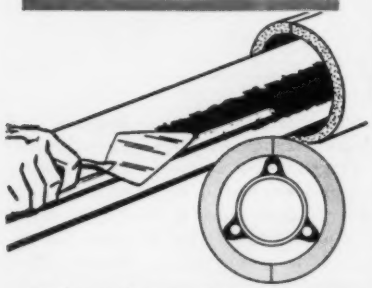
BARBER-COLMAN COMPANY

Dept. D, 1597 Rock Street, Rockford, Illinois, U.S.A.

BARBER-COLMAN of CANADA, Ltd., Dept. D, Toronto & Montreal, Can. Export Agent: Ad. Auriema, Inc., N.Y.

Sulphur Handling is No Problem with THERMON HEAT TRANSFER CEMENT





An increasing number of plants are using Thermon Heat Transfer Cement to eliminate sulphur handling problems encountered with internal tracing and steam jacketing. A non-metallic adhesive compound with highly efficient heat transfer properties, Thermon Heat Transfer Cement in sulphur installations

Eliminates misfitting of prefabricated pipe

Eliminates possibility of cross contamination

Eliminates need for stuffing boxes and packing glands

Reduces cost of installation by *at least one-half*

Reduces maintenance costs

Thermon has been used successfully on pumps, valves and pilot plant and other equipment in sulphur service. Investigate the problem-solving and money-saving properties of Thermon, the *proved* solution to heat transfer problems.

Write for Thermon Bulletin 300.

THERMON

THERMON MANUFACTURING CO.

1017 Rosine • P. O. Box 1961
Houston, Texas

119

Suppliers . . .

spectively. A similar change has been made by the Mexico Refractories Co. of Texas. District headquarters will remain at Houston with **L. L. Brightman** as manager. In Los Angeles, Missouri Refractories Co. has changed its name to Kaiser Refractories & Chemicals. **W. E. Daugherty** will be district sales manager. A new sales office has been opened at 2901 East 4th Ave., Columbus, Ohio, where **Glen Ames** will be sales representative.

MIDWEST PIPING CO. has named **Warren Smith** assistant director of manufacturing sales for welded fittings and flanges. He will work with Midwest field representatives from coast to coast to implement distributor sales, with headquarters in St. Louis. Smith has been with Midwest for eight years, as sales representative in New York, and more recently as sales manager, Pacific Division, Los Angeles. He is a former marine engineer, and until moving to St. Louis, was chairman of the Southern California Section, Society of Naval Architects and Marine Engineers.

Smith

BECKMAN INSTRUMENTS INC.'s Scientific and Process Instruments Division has appointed **Roy F. Brown** marketing manager. He will direct marketing of the division's products, including analytical instrumentation for laboratories, and industrial process control.

SOUTHWESTERN INDUSTRIAL ELECTRONICS CO. has named **Hugh A. Saye, Jr.,** assistant marketing manager, Controls Division. He will direct activities of SIE sales engineers in the process-industry automation field. Saye was formerly manager, CSC Division, Fisher Governor Co.

ALLIS-CHALMERS MANUFACTURING CO.'s Industrial Equipment Division has named **M. M. York** manager of marketing. He will be responsible for direction of sales and distribution activities of the division. York is an electrical engineer.

FOOD MACHINERY AND CHEMICAL CORP.'s Dr. Desmond M. C. Reilly, chemical advertising and publicity manager, has been named president of the National University of Ireland Club, N. Y. He is a 1945 graduate of NUI.

HOOKER CHEMICAL CORP.'s Western Chemical Division has named **James G. Baldwin** general manager, replacing **Horace W. Hooker,** who will move to the company's New York headquarters to assume new corporate duties. **Russell O. Vognild** becomes sales manager of the division succeeding Hooker.

CLEAVER BROOKS CO. is expanding its Wisconsin agency network by dividing

Choosing an Antioxidant?

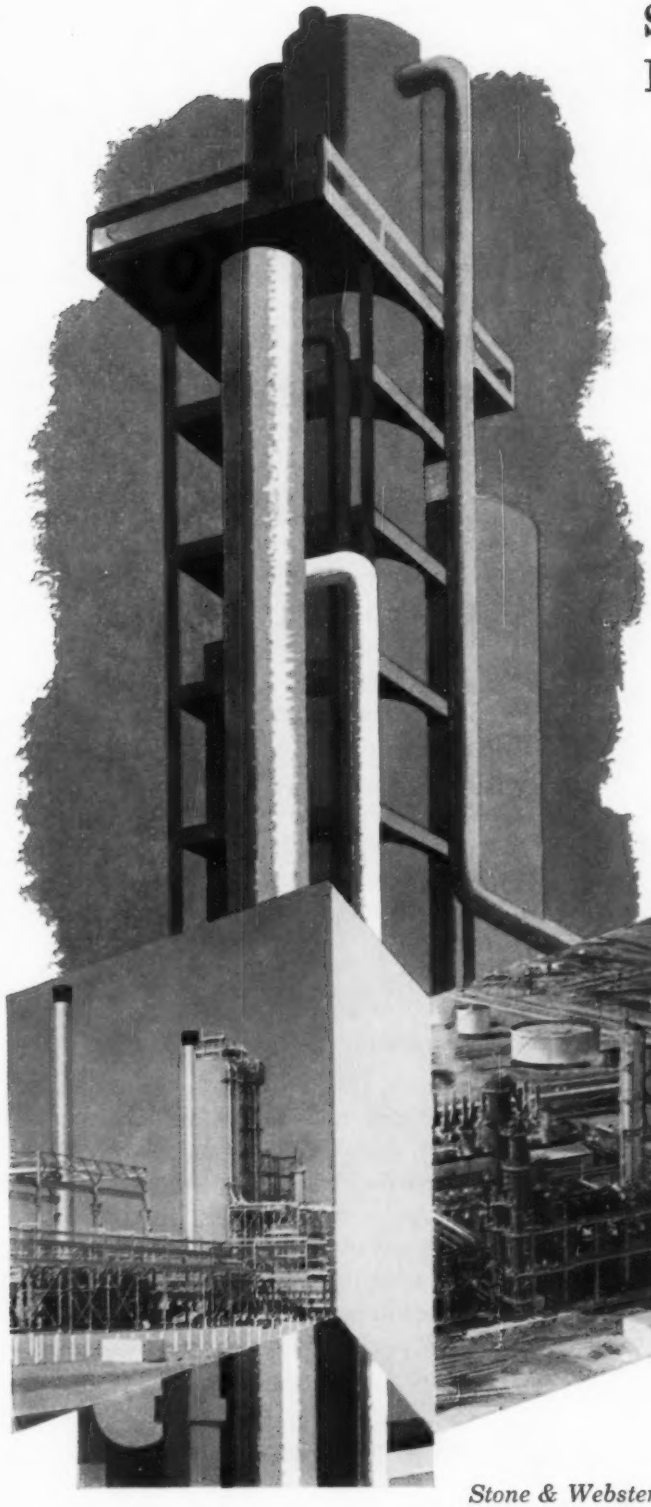
DALPAC® 4 SAVES YOU MORE

Refinery customers have found that, in comparison with other inhibitors, Dalpac 4 (Hercules 2,6-di-tert-butyl-p-cresol) saves up to three dollars on every thousand barrels of gasoline produced. Dalpac 4 inhibits gum formation, stabilizes gasoline color, and helps maintain engine cleanliness. Refiners have also found it to be excellent in turbine and transformer oils where it prevents deterioration, and does not affect electrical properties.

For additional information write:

Oxychemicals Division
Naval Stores Department
HERCULES POWDER COMPANY
900 Market Street
Wilmington 99, Delaware

NO59-5R

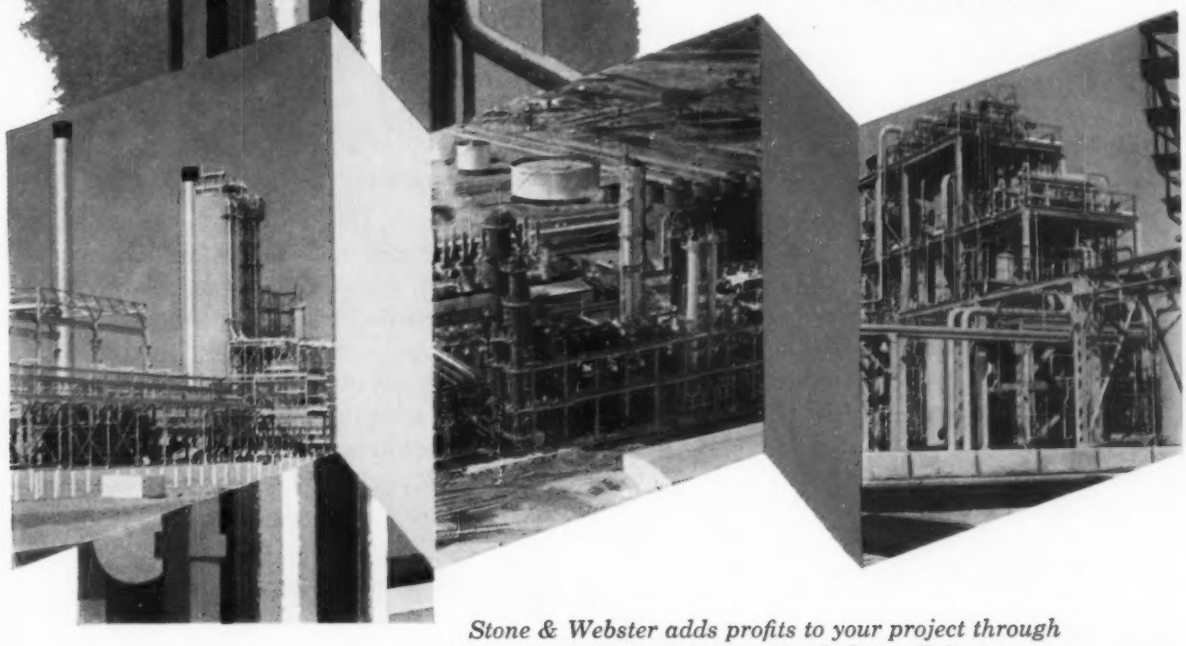


Stone & Webster Engineering Corporation

specialists in process profits

The variety of skilled engineering experience available at Stone & Webster has produced added operating efficiency and economy to hundreds of processing plants throughout the world. Stone & Webster engineers are specialists in process engineering . . . men trained to work as a team to meet time and cost budgets as well as production requirements.

Stone & Webster approaches each new project as a new opportunity for creative engineering directed toward lower investment and operating cost with resulting higher profit for the client. If you have an engineering problem Stone & Webster can help you solve it. Call or write our nearest office.



Stone & Webster adds profits to your project through engineering economies and plant efficiency.

STONE & WEBSTER ENGINEERING CORPORATION

AFFILIATED WITH STONE & WEBSTER ENGINEERING LIMITED (LONDON)

New York Boston Chicago Pittsburgh Houston San Francisco Los Angeles Seattle Toronto

LGP-30 COMPUTER ABSTRACTS

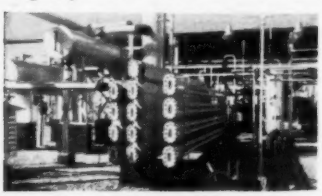
(Application Report #10, from which the following is abstracted, is free upon request from Royal McBee Corporation, Data Processing Division, Port Chester, N. Y.)

Subject: Design / User: Brown Fintube Company, Elyria, Ohio

THE PROBLEM: rush quotation for heat exchanger to potential customer. Determine best heat exchanger vs. cost combination. Perform necessary computations to obtain values for total surface area; total number of exchangers; area/exchanger; velocity and pressure drop – shell and tube; film coefficient; log mean temperature difference; overall transfer rate; clean rate; overall fouled rate; surface actually required; duty; price.

METHOD: the compact, low-cost Royal Precision LGP-30 Electronic Computer.

INPUT DATA: except for special specifications which are handled by design engineers, non-technical personnel fill in data directly from customer inquiry sheets. This information is then punched on tape.



SOLUTION: the engineer reads the above data into storage in specifically assigned memory locations on the computer's magnetic drum. The set of program instructions–also stored on the drum–then directs the computer where to find the input data and what mathematical operations to perform in the proper sequential order. The program then further directs the computer to store the various answers in specifically assigned memory locations.

Of notable interest is the incorporated test feature which allows any type and arrangement of sections to be tested by the computer. The program not only compares calculated values, but provides a corrective computation and recomputes all conditions until satisfactory values are obtained. The engineer need only type in the exact arrangement desired to have the computer calculate his proposed arrangement – assuring complete versatility and control over the program.

OUTPUT: all numbers required for the final specification sheet, including price, are provided – as well as key intermediate answers to enable the engineer to exercise judgment. The computer automatically controls the typewriter so that all answers are printed out in the desired format.

CONCLUSIONS: with the LGP-30, Brown Fintube has reduced total time on typical heat exchanger designs from one or two hours to approximately 3 minutes. Better design vs. cost combinations have been obtained–with a resulting increase in contract awards and the elimination of under-bidding. According to company officials, "perhaps the most significant contribution of the LGP-30 has been the release of engineering manpower for more basic and profound studies."

Royal Precision Corporation

Royal Precision is jointly owned by the Royal McBee and General Precision Equipment Corporations. LGP-30 sales and service are available coast-to-coast, in Canada and abroad through Royal McBee Data Processing offices. For your free copy of Application Report #10, as well as full specifications on the compact, mobile LGP-30, write today to **ROYAL McBEE CORPORATION,** data processing division, Port Chester, N.Y.

Suppliers . . .

the present agency, Dyke & Tutsch Co., into two separate agencies. The newly formed Dyke & Associates, Inc. will headquarter in Milwaukee, and the new Heat Exchange Products Co. will also locate there.

UNITED STATES STEEL CORP.'s National Tube Division has named **James E. McDonald** manager, mechanical and pressure tubing products. He attended Indiana University and served in the Army from 1943-46. In 1946 he joined National Tube Division at the Gary, Ind., works. McDonald became a sales trainee for National Tube in May 1948, and upon completion of his training course, was assigned to the Cleveland Sales District. In 1953 he was transferred to the Pittsburgh sales office where he has been until his present appointment.

McDonald

UNITED STATES RUBBER CO., Houston Branch, has named **John V. Glaves** district sales manager, replacing **J. Wesley Batten,** district manager, retired. Glaves has been with U.S. Rubber since 1948.

KEASBEY & MATTISON CO. has appointed **John F. Heaney** sales service supervisor, Perth Amboy, N. J., plant. With the company since September 1957, he was previously in the New York office. He has been in charge of customer service, Perth Amboy.

ARCAIR CO. has named **William Bajari** field representative, Bremerton, Wash. He will work with company distributors and call on industries in 13 Western states. **Richard Henderson** has been appointed chief engineer for the firm. He will be in charge of product design, research and development.

GENERAL ANALINE & FILM CORP.'s Antara Chemicals Division, has appointed The Chemical Sales Co., Denver, a distributor. The Denver firm will handle Antara's line of surfactants, sequestering agents, iodophors, glycols and other products.

FOOD MACHINERY AND CHEMICAL CORP. has appointed **Ralph Bloom, Jr.,** Washington, D. C., representative for the Chemical Divisions, replacing **Philip H. Groggins. Groggins** becomes senior scientific adviser.

CONSOLIDATED ELECTRODYNAMICS CORP. has elected **Dr. Kenneth W. Gardiner** chief research chemist. With the company since August 1959, he was previously director, General Chemistry Laboratory, Central Research Division, Continental Can Co.

CELANESE CHEMICAL CO. has named **John C. Jadel** a sales representative, Los Angeles office. Formerly with The Dow Chemical Co., he has been with Celanese since November. Jadel has a B.A. degree in chemistry and a M.B.A. degree.

AMERICAN POTASH & CHEMICAL CORP. has transferred **Dean L. Browne** from its Lindsay Chemical Division, West Chicago, Ill., to the Los Angeles office, where he will be market-development representative for the company.

FOOTE MINERAL CO. has authorized purchase of a 670-acre site in the New Johnsonville, Tenn., area, where it plans to build an electrolytic manganese facility. Foote operates two similar plants in Knoxville.

H. K. PORTER CO., INC. has named **C. P. Stewart** manager, trade relations. He joined the company three years ago in the Trade Relations Department. Stewart is a graduate of Harvard University.

HOKE, INC., has appointed J. R. Simpson Co. as its distributor in Northern Illinois, Southern Wisconsin, and Northwestern Indiana. **Greg Moody,** former distributor in this territory, has been appointed distributor in Florida.

WILKENING MANUFACTURING CO.'s David A. Cowhig, executive vice president, has been elected president of the Metal Manufacturers Association of Philadelphia.

NALCO CHEMICAL CO. has appointed **T. M. James** field personnel manager, Industrial Division, Chicago. He formerly was man-

MEETS YOUR
EXACTING REQUIREMENTS
in heat exchanger
rating
and
design

the KEMCO code / THOROUGH QUALITY CONTROL INSPECTION
SPECIFICATIONS MATCHED EXACTLY
DELIVERY WHEN PROMISED

We'd like to furnish you more information. Please write today for illustrated brochure and additional data on personnel, facilities and customers to:

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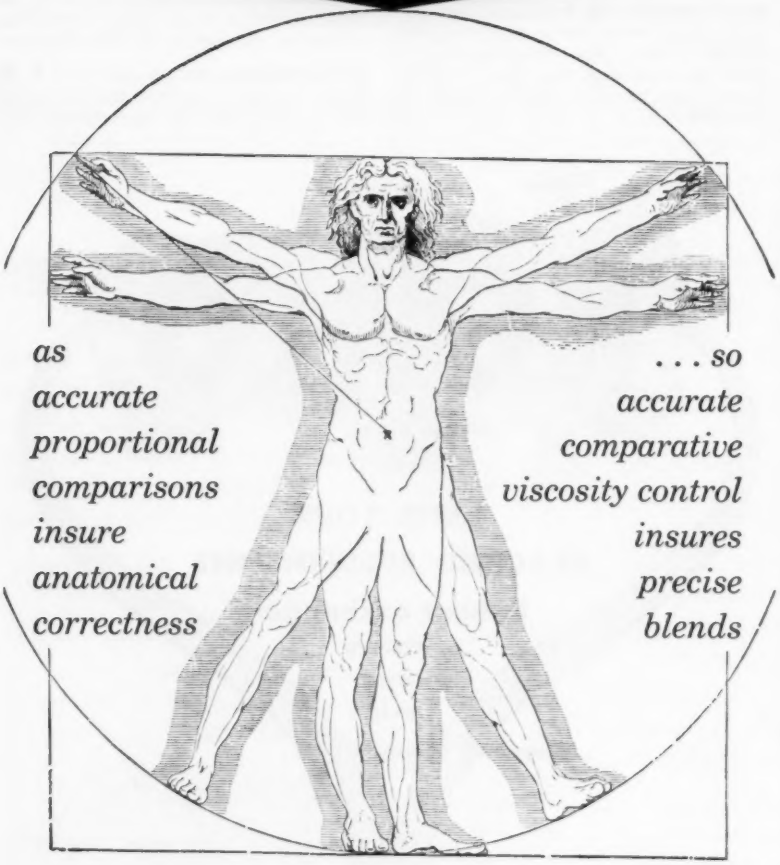
Offices in Oakland:
TEmplar 2-5391

For more data on advertised products, use Readers' Service Cards, last page

WHAT HAS THIS TO DO WITH VISCOSITY?



as accurate proportional comparisons insure anatomical correctness

. . . so accurate comparative viscosity control insures precise blends

and you can make them better with a

Bendix* Viscomparator

Accurate blending of petroleum products to a specification viscosity can be controlled continuously and automatically. The viscosity of the process fluid is compared with that of a reference sample at operating temperatures. Wide-range temperature compensation is inherent in the Bendix Viscomparator's design. Its sensing element withstands up to 650° F. (343° C.) and 1,000 psi.

For complete information about this surest, most modern method of controlling viscosity, write Dept. W-4.

*REG. U. S. PAT. OFF.

Cincinnati Division
3130 Wasson Road · Cincinnati, Ohio

Bendix
AVIATION CORPORATION

Export Sales and Service: Bendix International Division, 205 East 42nd Street, New York 17, New York
Canada: Computing Devices of Canada, Ltd., Box 508, Ottawa 4, Ontario

Suppliers . . .

ager of the division's Pacific Northwest District, Portland, Ore. **W. V. Cross** is being transferred from the Wisconsin District to succeed James as district manager, Portland, and **J. A. Manley** will replace Cross as manager, Wisconsin District.

CHIKSAN EXPORT CO., formerly a subsidiary of Chiksan Co., has become a division of the parent firm and has been renamed Chiksan International. The new International Division will maintain its headquarters at Brea, Calif. No personnel changes are involved.

BENJAMIN FOSTER CO. has named George Foster, Jr., vice president in charge of sales. Wayne Ellis has been elected vice president in charge of research.

KEASBEY & MATTISON CO. has named **DeWitt W. Keach** personnel manager for all its Ambler locations. Holder of a B.S. degree from Yale University, he was formerly assistant personnel manager of the Watkins Glen, N.Y., Division, International Salt Co.

KEASBEY & MATTISON CO. has named **Anthony A. Lowe** publicity writer in the Advertising Department. A former advertising assistant, he joined K&M in 1952. He is a graduate of the Charles Morris Price School of Advertising and Journalism, Philadelphia.

COOPER BESSEMER CORP.'s President **Eugene L. Miller** has been elected 1960 president of the Diesel Engine Manufacturers Association. He succeeds **John N. MacKendrick,** board chairman of Clark Brothers Co., Olean, N.Y.

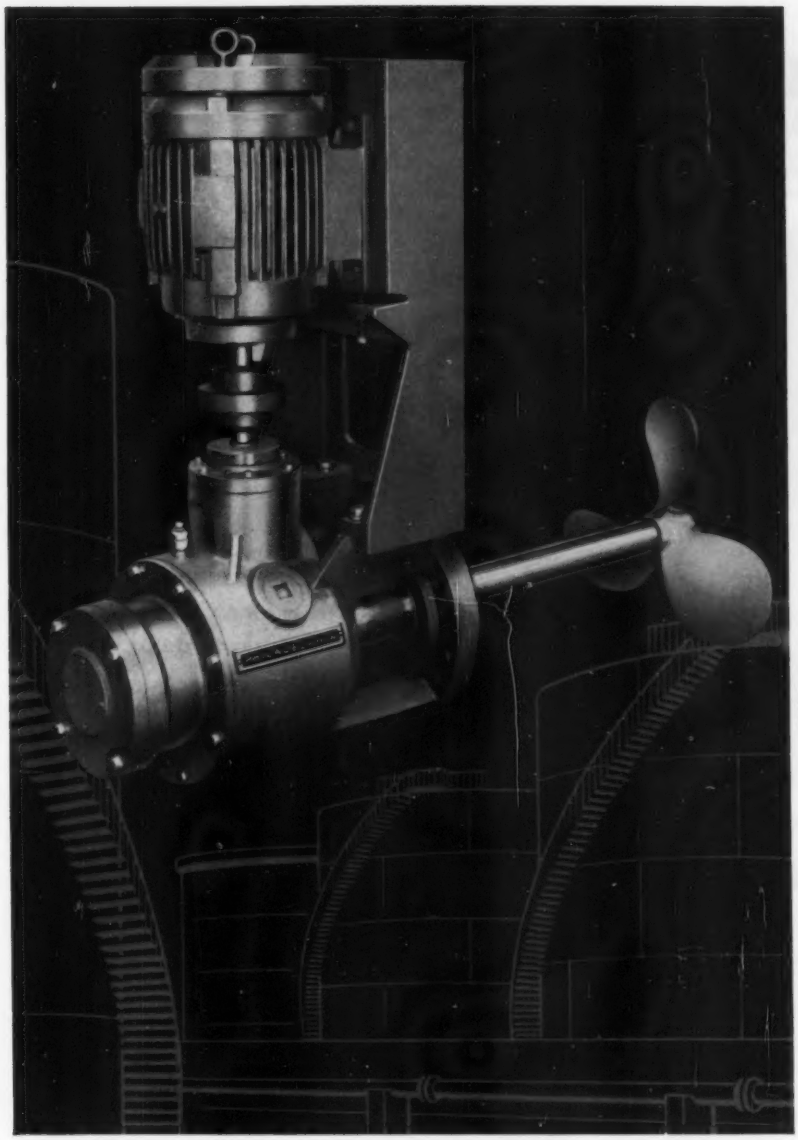
FAIRBANKS, MORSE & CO. has named **William G. Vollendorf** manager, Tulsa Sales District, succeeding **Kirke W. Wyatt,** promoted to manager of petroleum industry sales. Vollendorf joined the company in 1942, and Wyatt joined the company in 1945.

FLORIDIN CO. has opened new sales offices in New York, St. Louis and Dallas. They will enable Floridin to offer the petroleum and gas industries service on its earth adsorbents and activated bauxite desiccants. Floridin's general sales offices are in Tallahassee, Fla.

McKESSON & ROBBINS, INC. has moved its chemical warehouse and office facilities from South Norwalk to Stamford, Conn. The new facilities serve customers in Fairfield, New Haven and Litchfield Counties, and Westchester County, N.Y.

ELECTRIC-MESH CORP. has been purchased by American Chain & Cable Co. Founded in 1953 by **Paul A. Sutton,** Electro-Mesh will operate as an American Chain & Cable subsidiary.

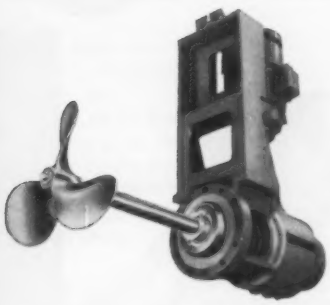
NATIONAL CARBON CO. has named **Fred B. O'Mara** director of manufacturing. To headquarter in Cleveland, he will be re-



NEW from Philadelphia... SIDE ENTERING MIXERS

And there is plenty that's *new* about them. Shorter, more compact; they minimize the need for mounting braces. Reducer and reducer support stand housing is one piece to provide more rigid support for bearings, shafting and gearing. In short, these new mixers are designed for the job . . . not adapted to it. They overcome all the problems inherent in mixers that are a collection of components designed for other purposes. And if you are looking for better mixing, these new Philadelphia mixers will deliver it. Large volumetric flow means thorough top-to-bottom turnover, even in the largest tanks. As for cost, Philadelphia side entering mixers cost less than *any mixer* of comparable quality.

NEW
FROM EVERY ANGLE



COMPACT. This is an extremely compact mixer. Weight is centered close to the tank wall. There's less overhang . . . less strain on tank walls and nozzles. Need for bracing at points other than the mounting flange is minimized.

HIGH CAPACITY GEAR REDUCER IN MIXER DRIVE. The capacity of the precision spiral bevel drive, using maximum standard motor sizes, is more than twice AGMA requirements. This means far greater gear life than normally required.

ONE PIECE GEAR REDUCER AND REDUCER SUPPORT STAND HOUSING. Rugged and rigid, it is designed for large, high capacity bearings, and large-diameter shafting. Result: truer running agitator shafting and reduced maintenance.

DEPENDABLE SHUT-OFF ARRANGEMENT. The mechanical seal is a cartridge unit. One man can change it quickly and easily with a full head of liquid in the tank, without moving the mixer in any way.

TRUE RUNNING SHAFTS. Minimum distance from reducer to shaft seal, combined with large diameter shafting, means less run-out at the seal. Mechanical seals last longer. Packed stuffing boxes require far less maintenance.

SIMPLE, FOOLPROOF LUBRICATION. Time-tested oil splash system provides correct lubrication to gears and bearings.

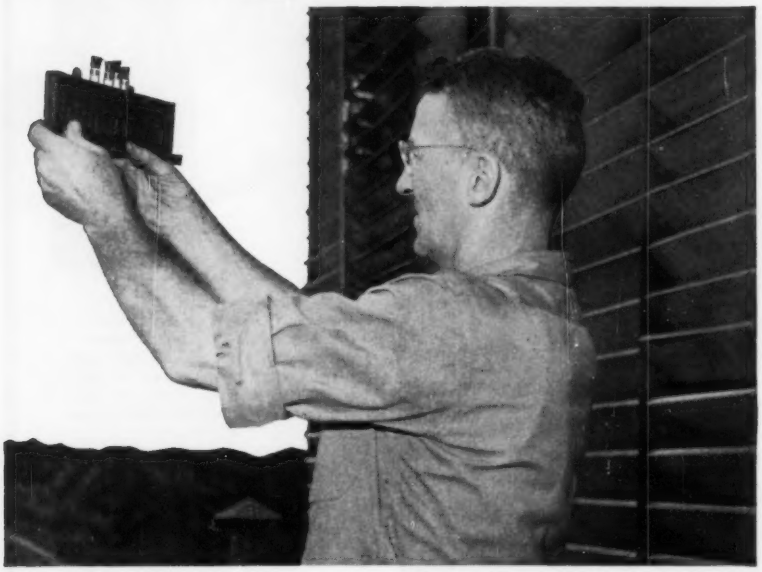
For better mixing, and a better mixer, get all the details. Write for Catalog PSE-60. Sizes: Model 08, 1 to 7.5 HP; Model 11, 10 to 25 HP.

PHILADELPHIA GEAR CORPORATION
King of Prussia, Pennsylvania
(Suburban Philadelphia)

philadelphia mixers

For more data on advertised products, use Readers' Service Cards, last page

BIRD-ARCHER'S 8 POINT WATER TREATMENT PROGRAM



Designed for Inplant Testing... Performed by Your Personnel... Backed by Experts

If you use water for power, process or cooling, it will pay you to look into Bird-Archer's 8 point Water Treatment Service. Every step in this Service is performed by qualified chemists and engineers whose main task is to design a system that can be implemented by *your own personnel* and at the same time place at your disposal *60 years' experience* in solving water treatment problems.

Bird-Archer's 8 Complete Engineering Services

- Complete studies of your use of water or steam.
- Exhaustive analysis of water supplies starting at source.
- Modern laboratory with seasoned chemists specializing in water analysis and research.
- Operational changes where necessary.
- Custom formulated chemical treatments for your specific needs.
- Complete analysis of savings and benefits where additional equipment may be helpful.
- Instruction of your personnel by experienced technicians in accurate control and test procedures.
- Periodic call-backs by your Bird-Archer Service Engineer to be sure you continue to get the best possible results.

A Bird-Archer 8 Point Service Engineer is only a "phone's throw" away. Call him for greater peace of mind.

8A-900

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WATER TREATING CONSULTANTS
The BIRD-ARCHER Company, 4337 N. American St., Phila. 40, Pa.
New York • Chicago
The BIRD-ARCHER CO. of California, 415 Brannan St., San Francisco • Offices in Canada and Mexico

Suppliers . . .

sponsible for all manufacturing operations at company plants in Cleveland and Fostoria, Ohio; Clarkburg, W. Va.; Columbia and Lawrenceburg, Tenn., and Niagara Falls, N.Y.

HARBISON-WALKER REFRACTORIES CO. has named **Charles D. Gabor** chief engineer. With the company since 1941, he has served as a draftsman in the Engineering Department, in general engineering work, and as a project engineer. In 1957, he was appointed assistant chief engineer. A professional engineer, Gabor spent 16 years at the Carnegie Institute of Technology night school, in Pittsburgh, working for his B.S. degree in mechanical engineering, which he received in 1953.

Gabor

FARRIS ENGINEERING CORP. has appointed C. L. Boyer & Co., Billings, Mont., field sales representative. C. L. Boyer will sell and service the Farris line of valves for the petroleum, petrochemical and chemical industries.

ROBERTSHAW-FULTON CONTROLS CO. is negotiating for a cash consideration in the instrument business of Manning, Maxwell & Moore, Inc. The line of instruments would be integrated with industrial instrument products of Robertshaw's Aeronautical and Instrument Division.

STONE & WEBSTER ENGINEERING CORP. has named **George W. Letteney** assistant treasurer. With the company since 1942 as an accounting supervisor, he was previously with Dover Stamping & Manufacturing Co.

BARBER-COLMAN CO.'s Wheelco Instruments Division has established a regional sales and service office to serve Arizona, California, Nevada, Oregon and Washington. **W. F. Paetz,** Los Angeles Branch sales manager, will manage the new operation.

NALCO CHEMICAL CO.'s Robert R. Burns has been appointed manager, Commercial Development Department. Formerly product manager for industrial process chemicals, Burns has a chemical engineering degree from Oklahoma A & M College.

GRAVER TANK & MANUFACTURING CO. has named **John V. Page** controller succeeding **William Hopewell,** who recently resigned. Page was previously executive vice president and treasurer, Rayette, Inc., St. Paul, Minn.

FISCHER & PORTER CO. has named **Robert M. Lewison** manager, International Division. A mechanical engineering graduate of Lehigh University, he has been assistant International Division manager

Bristol Dynamaster* Electronic Instruments have proved themselves in thousands of installations. They fully meet today's most exacting standards of accuracy and dependability. They measure almost any variable that can be translated into an electrical quantity (d-c current, d-c voltage, resistance or capacitance). Just a few are: temperature, pH, speed, voltage, smoke density and strain.

Here are some outstanding features that make them ideal for industrial plants, pilot plants, and for research, test, and laboratory use:

1. Continuous standardization—eliminates standardizing mechanism and dry cell—no interruption to control. **But retains precision standard cell for highest accuracy and stability.**

2. Simple design—few moving parts.

3. Easy to use and service—little or no maintenance required.

4. Rugged construction—unaffected by vibration.

MODELS FOR EVERY PURPOSE. Dynamaster Instruments are now available as:

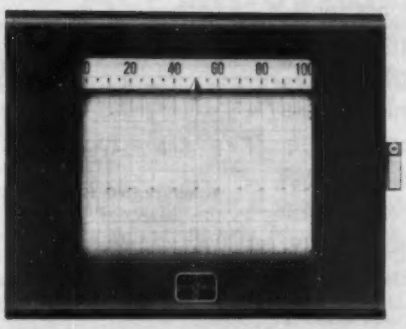
A. Single-pen, two-pen, and multiple-record (up to 24 points) strip-chart instruments.
B. One- and two-pen round-chart recorders.
C. High-speed recorders (0.4 second).
D. X-Y recorders.
E. Extended range recorders.
F. Adjustable span and zero recorders.
G. Miniature 3-inch strip-chart recorders.
H. Electric controllers in both strip- and round-chart models—all types of control action and as time-program control.
I. Pneumatic controllers in both strip- and round-chart models—all types of control action and time-program control.
J. Instruments for electronic measurement—pneumatic transmission of reading by 3-15 psi signal.
K. Round chart program controllers.
L. Telemetering transmitters.
M. Drum-type precision indicators.
N. Multi-bank recorder—will accept up to 200 separate inputs and record them on 12-inch wide strip chart.
O. Relay-rack mounting models—most models available in case that fits standard 19" relay-rack without modification to instrument or rack, without panel-cutting or masking.

Bristol Dynamaster Potentiometer and Bridge Instruments can be equipped with analog-to-digital encoders of various types for digital readout and computer use. For complete details, write for Bulletins P1245A, P1270, P1271, P1242, and P1282. The Bristol Company, 111 Bristol Road, Waterbury 20, Conn.

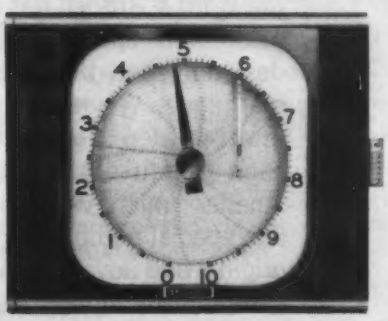
*T. M. Reg. U.S. Pat. Off.

look to Bristol for the complete line of

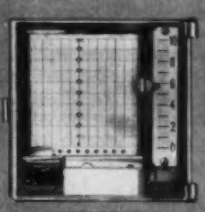
ELECTRONIC POTENTIOMETER and BRIDGE INSTRUMENTS



Dynamaster* Electronic Potentiometer or Bridge—records on 11-inch, 120-foot-long strip chart.



Dynamaster* Electronic Potentiometer or Bridge—records on 12-inch round chart, indicates on extra-large scale.



RECORDER

INDICATOR

Plug-in Miniature Electronic Dynamaster Potentiometer and Bridge Instruments—Only 5" x 5⅛" panel dimensions; ideal for graphic panel instrumentation.

BRISTOL

TRAIL-BLAZERS IN PROCESS AUTOMATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

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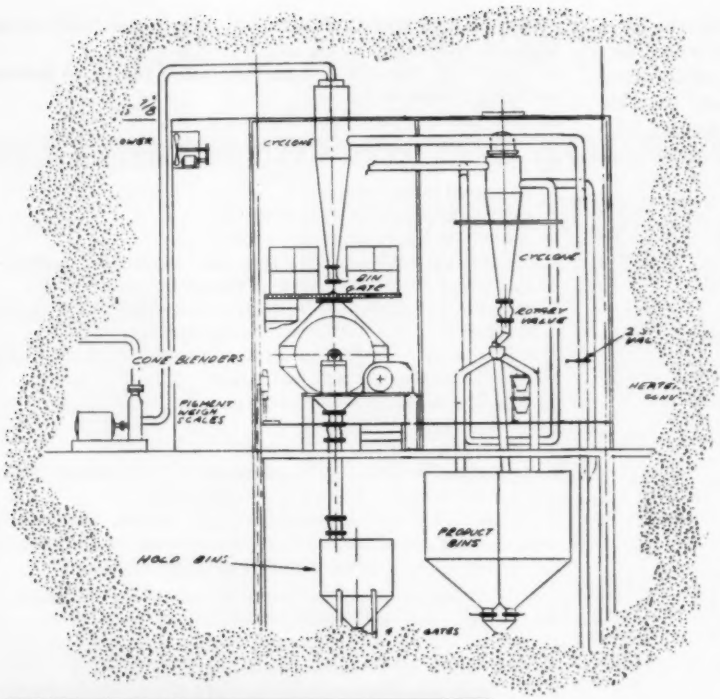
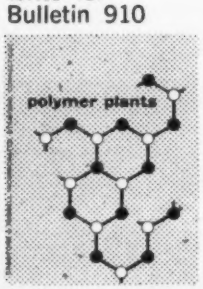


POLYMER PLANT ENGINEERING

Crawford & Russell has the largest technical staff specializing exclusively in designing and building complex polymer plants. We are now designing three multi-million dollar polymer plants, each the first of its kind, and many smaller units. We build pilot plants and special equipment. Our designs are original and advanced—our services are completely confidential.

Write for Bulletin 910



complete plants: RESINS • PLASTICS • SYNTHETIC RUBBERS

MONOMER ⟶ POLYMER ⟶ FINISHED PRODUCT
POWDER
PELLET
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EXTRUSION
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EMULSION

CRAWFORD & RUSSELL
INCORPORATED
695 SUMMER ST., STAMFORD, CONNECTICUT

Suppliers . . .

for the past three years. He is a member of ASME and ISA.

BECKMAN INSTRUMENTS, INC. has named **Kenneth C. Moulton** executive vice president. Formerly with Daystrom Inc.'s Daystrom-Weston Sales Division as general sales manager, he will be responsible for coordinating marketing activities of all Beckman divisions, appraising marketing opportunities and contributing to the development of programs to fully exploit such opportunities. At Daystrom he served as Southern California district manager; assistant general sales manager, Weston Instruments Division; and most recently as general sales manager, Daystrom-Weston Sales Division.

Moulton

TRETOLITE CO. has appointed **Amos J. Fox** to its administrative sales staff, St. Louis. Formerly Latin American Division manager, he will assist sales manager **James E. Stockton, Jr.,** and cover the South and Southwest United States.

GENERAL PRECISION, INC.'s Librascope Division has appointed **Hugh Jacobson** manager, systems sales, Burbank, Calif. He will direct national sales efforts for the division's process control systems. Jacobson has been with the firm since 1958.

CHEMETRON CORP.'s Tube Turns Division has appointed **Jack D. Tolliver** field sales manager. Formerly Eastern Region sales manager, he will supervise sales in all U.S. district-office territories. Tolliver is a mechanical engineer.

SUNDSTRAND HYDRAULICS CO. has joined the Material Handling Institute along with Minneapolis-Moline Co. and Vac-U-Lift Co. The three new member-companies were admitted to membership in March.

TRETOLITE CO.'s vice president of research, development and patents, **Melvin De Groote,** has retired. He will continue with the company as a consultant, and maintain offices at Petrolite Corp.'s Webster Groves, Mo., headquarters.

B-I-F INDUSTRIES, INC. has elected **Rudy P. Lowe** vice president. With the company since 1932, he continues as director of industrial systems sales. Lowe has a B.S. degree in mechanical engineering from Illinois Institute of Technology.

GENERAL AMERICAN TRANSPORTATION CORP. has named to its board **Adm. Louis L. Strauss** and **J. Richard Scanlin.** Adm. Strauss was a director of the company from 1950-53, when he joined the Atomic Energy Commission. Scanlin is sales manager, New York.

For more data on advertised products, use Readers' Service Cards, last page

Petroleum Refiner Classified Ads

SITUATIONS WANTED

■ Underground mined L.P.G. storage cavern Supt. available. Can take over complete construction. Knowledge of planning, estimating, material, latest and cheapest methods and equipment. Can assist in drawing recommended plans and specifications. Can supply key men. Salary plus % profit. Contact K. D. Barton, P. O. Box 56, Roslindale, Mass.

HELP WANTED

SENIOR PROCESS ENGINEERS

Permanent employment with an expanding company. Excellent advancement opportunities for men with at least 10 years experience in process design of petroleum and petro-chemical plants.

Send detailed resume to:

G. VICTOR HOPKINS

ARTHUR G. McKEE & CO.

2300 Chester Ave., Cleveland 1, Ohio

HELP WANTED

REFINERY MAINTENANCE—Two men, one possibly for Maintenance Superintendent, with several years general experience in all phases refinery maintenance: covering, welding, pipe fitting, pump and compressor repairs, instrument, electrical, boiler making, rigging, etc. Mechanical Engineering Degree desirable but not necessary if otherwise qualified. Must be capable of doing work in the crafts themselves, also organizing, training, and supervising our Puerto Rican employees. Salary commensurate with experience and ability. Make application to E. G. Case, Vice-President, Manufacturing, Caribbean Refining Company, Box 2988, San Juan, Puerto Rico.

ASST. PLANT ENGINEER

for assuming direct responsibility for **maintenance function. M.E., PET. E., or Ch.E.** degree with 3-5 years supervisory maintenance experience in **petroleum refinery** would be most suitable.

Through **promotions** and **expansion** this opening is available for a young man ready to step up to greater responsibilities.

Our Company is a **chemical processor** with a variety of maintenance functions because of diversified unit operations involving widely divergent conditions.

Please write in confidence with full information to:

JOHN W. CHURCH,
Personnel Manager
Armour Industrial Chemical Co.
110 N. Wacker Drive
Chicago 6, Illinois

HELP WANTED

CHEMICAL ENGINEERS

All Degree Levels Needed Immediately for Process Design and Economic Evaluation

Apply your abilities to the development and design of new process units in the Petroleum Refining, Chemical Processing, Plastics, and all related fields. Two to five years' experience is preferred. Salary commensurate with experience. Location in Bartlesville, Oklahoma, a modern, progressive, southwestern community.

PHILLIPS PETROLEUM COMPANY

offers you a challenge and opportunity. Do not delay, write - - -

Personnel Procurement
Research and Development Department
PHILLIPS PETROLEUM COMPANY
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SERVICES

NORMAN O. ELDRED
Consulting Chemical Engineer
P. O. Box 3396, Mdse. Mart Postal Sta.
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Complete Petroleum Refinery Design Engineering, Bulk Gasoline and Oil Storage and Terminal Plants, Butane and Propane Storage and Vaporizer Plants Process, Finished Designs, Specifications, Reports, Supervision.

ACF INDUSTRIES, INCORPORATED

ALBUQUERQUE, NEW MEXICO

Opportunities For

ENGINEERING AND TECHNICAL PERSONNEL

PROJECT ENGINEERS

Graduate engineers in mechanical and chemical engineering with three to five years experience at least two of which should have been devoted to project engineering planning, project coordination, design analysis, and report preparation. Applicants are expected to assume broad responsibilities for planning and execution of challenging projects involving original engineering work.

PLASTIC ENGINEERS

Project engineers with degree in chemical or mechanical engineering and several years experience in one or more of the following technical areas: POLYURETHANES, REINFORCED PLASTICS, PRECISION MOLDING, MATERIAL SELECTION AND EVALUATION, EQUIPMENT DESIGN. Must be able to assume over-all responsibility for evolution of process and product development from laboratory to large scale production as well as design of production facilities.

CHEMICAL ENGINEERS

B. S. in chemical engineering with one to three years experience in heat transfer analysis. Mathematics through partial differential equations, and conformal mapping helpful but not mandatory.

MECHANICAL ENGINEERS

B. S. in mechanical engineering with one to three years background in stress analysis and heat transfer. Sought are analytically inclined engineers with mathematical acuity for the handling of a wide variety of problems including testing and data reduction.

ACF Industries, Incorporated, Albuquerque Division, is a prime contractor for the Atomic Energy Commission. Albuquerque is located in the rapidly expanding Southwest with a high, dry, mountainous climate, adequate schools, churches, and recreational facilities. U. S. Citizenship is required.

Send resume to: R. L. HANSEN, Employment Section, P. O. Box 1666, Albuquerque, New Mexico.

CLASSIFIED

Chief Engineer - General Manager

for young rapidly growing engineering organization specializing in petroleum, chemical, power plant, pulp, marine and structural. Excellent opportunity for ambitious man looking for promotion, who is experienced in organizing and directing projects utilizing civil, mechanical, electrical and chemical engineers. Company does engineering work for associated companies acting in above fields. Applicant must be able to plan, schedule and direct work and be cost conscious. Write in confidence to

J. D. Park, Jr.,
President,

Engineering Consultants Limited,

P. O. Box 279,

Saint John, New Brunswick

Suppliers . . .

CLIMAX MOLYBDENUM CO. has named **C. Eric Ho** manager of catalyst sales and development. In addition to marketing responsibilities, Ho will be providing developmental assistance and technical service to catalyst manufacturers, petroleum refiners and chemical manufacturers. He has been with Climax since 1958, serving until now as assistant director of marketing research. Before joining Climax, he was with Esso Standard Oil Co. in refinery process engineering, economic evaluation of new processes and planning of refinery capital expenditures.

Ho

GLASCOTE PRODUCTS, INC., a subsidiary of A. O. Smith Corp., plans to double present production facilities. In addition, the firm will add a new rail spur, heavy-duty cranes, and expanded and improved furnace sizes.

UNION TANK CAR CO. has nominated four business leaders as new directors. They are **Bennett Archambault,** Stewart-Warner Corp.; **Robert P. Gwinn,** Sunbeam Corp.; **William V. Kahler,** Illinois Bell Telephone Co.; and **Kenneth V. Zwiener,** Harris Trust and Savings Bank.

VULCAN CONTAINERS INC. has installed teletype sending and receiving equipment at Bellwood, Ill. The company's new TWX number is Bellwood Ill 2375.

GARLOCK PACKING CO.'s board chairman, **R. M. Waples,** has retired from active service. During his 40 years' service with Garlock, he advanced from file clerk to board chairman. He was company president, 1955-59.

Test Yourself on Labor Relations

(Answers—Quiz on Page 217)

CASE 1

Arbitrator Paul Prasow ruled:

"The Arbitrator is of the opinion that laid-off or terminated employes still retain some status with the company. The 'seniority section' of the agreement provides that an employe's seniority shall continue to be effective even while on layoff, provided his absence from the payroll does not exceed one year. That is, a laid-off employe, even though he is terminated, does not sever his entire relationship with the company until a year has gone by. In this sense his status is quite different from an employe who has been justifiably discharged. It is generally held by arbitrators that, unless the contract specifies otherwise, employes who are laid off within a reasonable period prior to a holiday *should be paid* for such holiday. The basis for this view is that the employe has met the basic conditions which qualify him for holiday pay, and that his being unable to meet other conditions because of some action by the company should not disqualify him from receiving such pay. The employes are to be paid for the holiday."

CASE 2

Arbitrator Arthur Stark ruled:

"Management cannot be expected to assume undue risks or to assign a man who cannot safely fulfill all the requirements of the position. The evidence clearly shows that safety was the primary and only reason for Johnson's being passed by. On the other hand, there is no evidence to show that Johnson's actions would be any different in the future. In the light of the above, the grievance is denied. The company is justified in denying the promotion to Johnson."

CASE 3

Arbitrator Paul Pigors ruled:

"With no established rule against dual employment, and without evidence that Mr. Armand Charpentier failed to measure up to his assigned responsibilities, this Arbitrator can only conclude that Mr. Charpentier's dismissal was without just cause. He should be reinstated with all his rights restored."

THE GARLOCK PACKING CO. has declared a 30-cent-per-share dividend for the first quarter, 1960. The dividend for the first quarter, 1959, was 25 cents per share. Gross sales for the first two months, 1960, were 10 percent higher than the same period in 1959.

REPUBLIC FLOW METERS CO., subsidiary of Rockwell Manufacturing Co., has moved its New Orleans office to 5534 Canal Blvd. The office is managed by **George Reech,** and **Cecil Lyle** is service engineer.

H. K. PORTER CO. has appointed **Fred W. Elliott, James A. Drain, Emmett H. Mann** and **B. Campbell Blake** group vice presidents. Each will have responsibility for a group of the company's divisions.

GENERAL AMERICAN TRANSPORTATION CORP.'s 1960 profits will be "the best in the company's history," according to **W. J. Stebler, president.** In a letter to shareholders, he pointed out that 1959 was the seventh consecutive year that the annual dividend has increased.

HOKE, INC. has appointed **K. C. Brown Co.** distributor for Kansas and Western Missouri. In operation since 1953, K. C. Brown has Kansas City headquarters. It will be a stocking distributor.

A. M. BYERS CO. has named **H. K. Siefers, Jr.,** manager, Engineering Service Department. With the company since 1956, he was previously with Hall Laboratory Division, Hagan Chemicals & Controls.

FOR SALE

■ FOR SALE—Asphalt Unit—1000-barrel capacity consisting of vacuum pump complete with vacuum jugs and 2 vacuum towers, 20-horsepower GE 220/440 volt motor; one 3000-barrel and two 2000-barrel all welded tanks insulated; miscellaneous asphalt heaters; cooling tower; loading racks; lab equipment, etc. Write Box 637, Hardin, Montana. Phone 642.

REFINERY INSPECTION GAUGES

JOHN J. BECKER CO.
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Send for your **FREE** copy of the **New Petroleum Books Catalog** containing descriptions of many books pertaining to the Petroleum Industry. Send your request to **Book Department, Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas.**

ENGINEERS

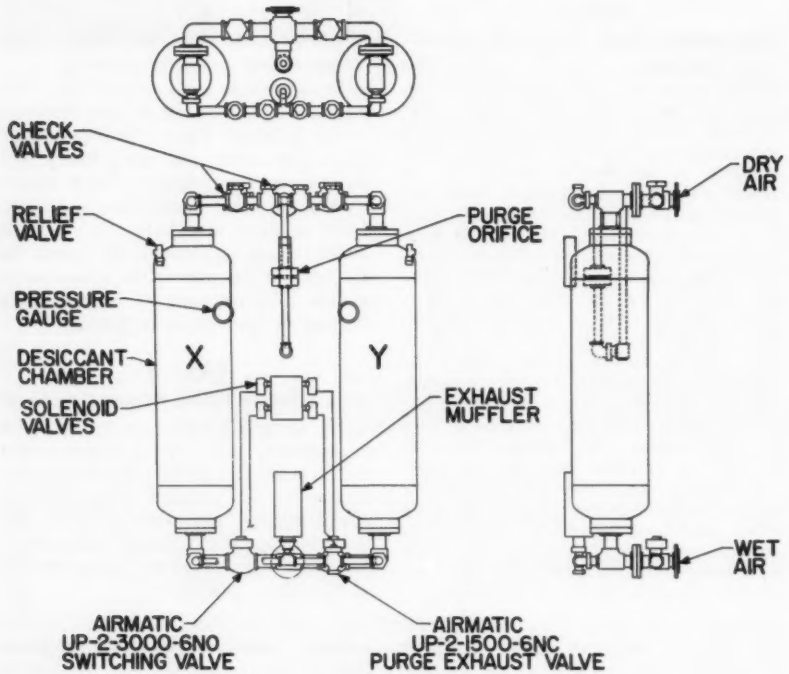
Major Company is developing an extensive diversification program calling for a wide variety of top-level talent as follows:

1. Chemical or petroleum refining process design, project development and/or operation.
2. Air separation plant design and operation or related cryogenic experience.
3. Hydrocarbon extraction design or operation experience.
4. Engineering Economic evaluation.

Prefer minimum of five years experience applicable to any one or combination of above.

Address replies with full resume in complete confidence to:
Box 335-R, PETROLEUM REFINER, Houston, Texas.

New Equipment & Literature...



Dehumidifier Saves on Labor, Maintenance

A new dehumidifier at Mobil Oil Co.'s refinery near Beaumont, Texas, is making substantial savings in labor while at the same time piling up an enviable maintenance record. In nine months time only one part, a check valve, has needed replacement.

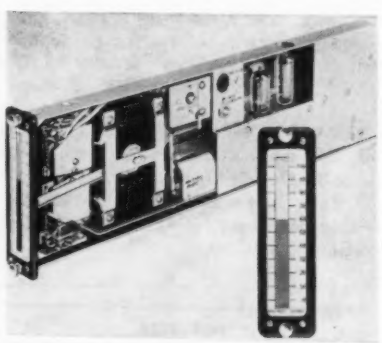
Even more important, the Heat-Les dryer does not need an operator to switch from one drying chamber to another. The equivalent heat-regeneration dryers used at Mobil require 1 to 1½ hours of an operator's time for switching every 8 hours or less. The heatless dryer switches every minute automatically and requires none of the operator's time.

Operation of the dryer is relatively simple. It uses twin beds of desiccant (as do heated dryers) one of which is on the stream removing moisture from the air, and the other is being regenerated. However, the new dryers have an advantage over heated dryers because maintenance costs are lower due to the elimination of heaters and coolers. Costly electric or steam heating is not needed. And the low temperature of heatless dryers virtually eliminates corrosion problems.

For its success, the new dryer depends on pressure differentials and the tendency of desiccants to come to equilibrium with their environments. The higher the pressure of the incoming air, the more efficient the operation. At Mobil, air enters the dryer at about 100 psi. The Airmatic valves direct the stream of compressed air into one of the tanks where its water-vapor load is adsorbed by the drying media or desiccant. (There is 732 pounds of desiccant in each chamber.) Part of the dry air emerging from the tank is directed to a passage which leads to the other tank. While the dry air is in this passage it is expanded to atmospheric pressure. The back flow of dry air picks up the moisture deposited there on the previous cycle and is then discharged to the atmosphere. The purge air stream has an enormous capacity for moisture because it was dried to a low dew point at 100 psig pressure and thus has a corresponding lower relative humidity at atmospheric pressure. Just before the switching valve change, the Airmatic valve closes and the purge air repressurizes the tank. Then the switching valves operate and the tank just repressurized becomes the drying tank while the other tank is quickly vented to the atmosphere, through the purge valve and the muffler. This sudden expansion of air in the tank removes a great deal of the moisture adsorbed on the desiccant. This occurs because sharply reducing the pressure causes the relative humidity to decrease rapidly (although the air within may have been nearly saturated before the pressure was reduced).

Mobil uses the heatless dryer in a system with three conventional heat-type dryers. The system is used to supply air to about 10,000 instruments in various parts of the refinery. The amount of purge gas required to activate the heatless dryer is about 20 percent of the inlet flow. However, the cost of the purge air is considerably less than the comparable cost of the heat energy and purge air requirements of a heat-regenerated dryer. Trinity Equipment Corp.

Circle E1 green card, last page



Panel Ribbon Indicator

A new electronic ribbon indicator measuring only 2 inches by 5 3/16 inches has just been introduced for use in regular panels where space is limited, or in graphic panel installations. Catalogued as the A22M, the minimum-dimension indicator can be mounted vertically, or in a left or right horizontal position.

The A22M is a high-amplification, null-balance device that operates on the common 0 — 0.5 V ac signal with accuracy of ± 1 percent of full signal input. It can be supplied with one (high or low) or two-alarm contacts.

FOR MAXIMUM SERVICE SPECIFY

B&W *Job-Matched seamless pressure tubing*

B&W offers you . . .

- sound engineering assistance on tubing end-use and fabricating requirements
- mutual understanding toward achieving the most satisfactory and economical tube performance
- the extensive facilities of 2 tube mills—plus a nationwide network of district sales offices and steel service centers manned by *experienced* tube salesmen—equipped to serve you with efficiency and dispatch

These are just a few of the many reasons why it pays to specify B&W Carbon or Alloy Seamless Pressure Tubing or Pipe. And remember—matching tubes to jobs assures you the *right tube,* in the *right quantity,* at the *right time.* For more information, call your local B&W District Sales Office, or write for Bulletin TB-417. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

TA-9055-SP2

B&W THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION

Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals

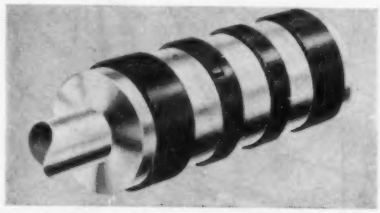
Equipment . . .

The design of the new indicator is simple as well as compact. The ribbon-drive mechanism and amplifier are mounted on the main chassis. For purposes of convenience, the amplifier assembly is a self-contained unit that may be removed in its entirety if replacement is necessary. Only zero and span adjustments are necessary, and both can be made from the front of the panel with the indicator only partially withdrawn. A magnetic switch linked to the connector lock in the mounting frame disconnects power from the unit before the cable connector can be removed, making the A22M suitable for use in Division 2 area. Swartwout Div., Crane Co.

Circle E2 green card, last page

Teflon Piston Rings

Filled Teflon piston rings, offering all of the chemical and mechanical advantages of this versatile fluorocarbon resin, are being marketed. The new piston rings



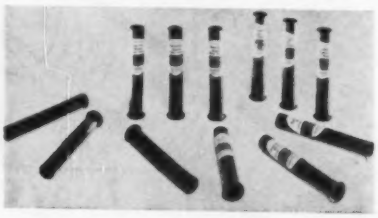
are ideal for non-lubricated service to seal reciprocating, oscillating and rotary motion of both external and internal cylindrical surfaces against the leakage of liquids or gases. Matched filled Teflon rider rings are also available for use in conjunction with the rings where long stroke or heavy pistons necessitate additional support.

The piston rings are made from specially processed carbon-filled Teflon which exhibits a lower coefficient of friction than any other solid material. They have exceptional thermal stability and are suitable for continuous service in a temperature range from —420 to 500° F. These rings are tough, abrasion-resistant and have the ability to imbed hard foreign particles without adversely affecting the cylinder life or the ring itself. Mechanical strength and dimensional stability are excellent. The Garlock Packing Co.

Circle E3 green card, last page

Teflon Protector Tubes

Fluoroflex-T protector tubes made of Teflon (TFE fluorocarbon resin) to prevent erosion and dew-point corrosion at the tube-sheet opening of heat exchangers



and condensers are being manufactured.

The tubes, tapered at the end to reduce turbulence, are easily installed by means of a hand press fit. They are inert to all chemicals and acids except molten alkali metals and fluorine at elevated temperatures and pressures. The protector tubes withstand temperatures from —100 to 500° F. They are non-aging and non-flammable. Resistoflex Corp.

Circle E4 green card, last page

Improved Pipe Insulation

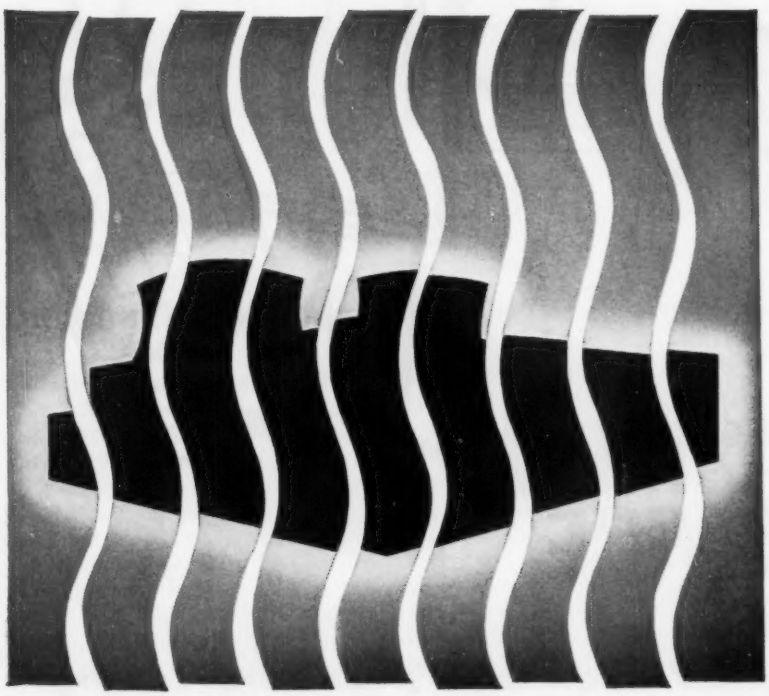
Major improvements have been made to Armaflex foamed-plastic pipe covering insulation to give it a higher temperature range, complete ozone resistance and smoother surface for easier handling and

better appearance.

Armaflex 22 can be used from below zero up to 220° F. It is ozone resistant and can be applied to sharp bends and elbows without danger of fissuring or cracking at the area under strain.

The improved product, with the average density reduced to 7 pounds per cubic foot, has an exceptionally smooth, uniform outer surface finish. This results

Put Darlington insulation on . . .



. . . wherever waste heat comes off

In atomic power stations and oil refineries, in ships and schools and sealing wax plants, Darlington Insulation is cutting heat losses, reducing fuel consumption and saving money for industrial and commercial firms of all kinds.

With Darlington Insulation you can reduce your heat losses by up to 90% —and that means big savings on your fuel bill. Whatever your heat waste problem, there is a Darlington insulating material that can solve it. Why not ask our Technical Division for advice and assistance ? Simply write to :

THE CHEMICAL & INSULATING CO. LTD.

Darlington, Co. Durham

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THE CHEMICAL & INSULATING CO. LTD. IS A MEMBER OF THE DARLINGTON GROUP OF COMPANIES

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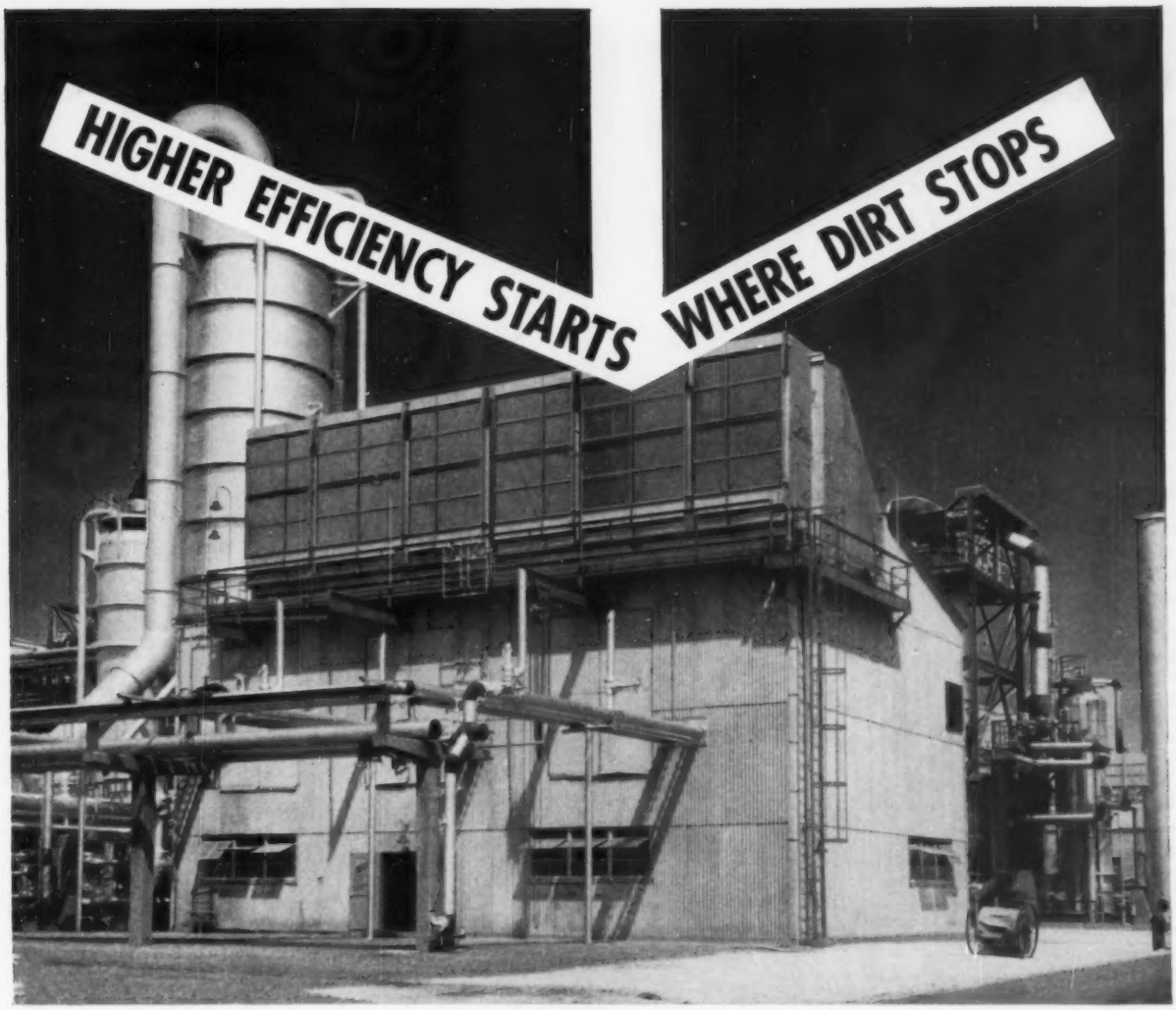


AAF cleans and cools intake air, helps boost petrochemical output

At Odessa Budadiene Co., Odessa, Texas, they're using the hot exhaust from two gas turbines to regenerate catalysts in the manufacture of budadiene.

A combination of MULTI-DUTY automatic, self-cleaning filters and Amer-Kool evaporative coolers assures clean, cool intake air for both 8500-HP turbines. The automatic intake filters operate continuously, while the evaporative coolers are operated only when ambient temperatures necessitate cooling the air for increased turbine output.

Whether your operation is in a hot and dusty desert, a temperate region, or the Arctic — whether the application is one of process or pumping — whether your station is automatic or attended, portable or stationary — AAF has air filtration equipment *engineered* to match your requirements!

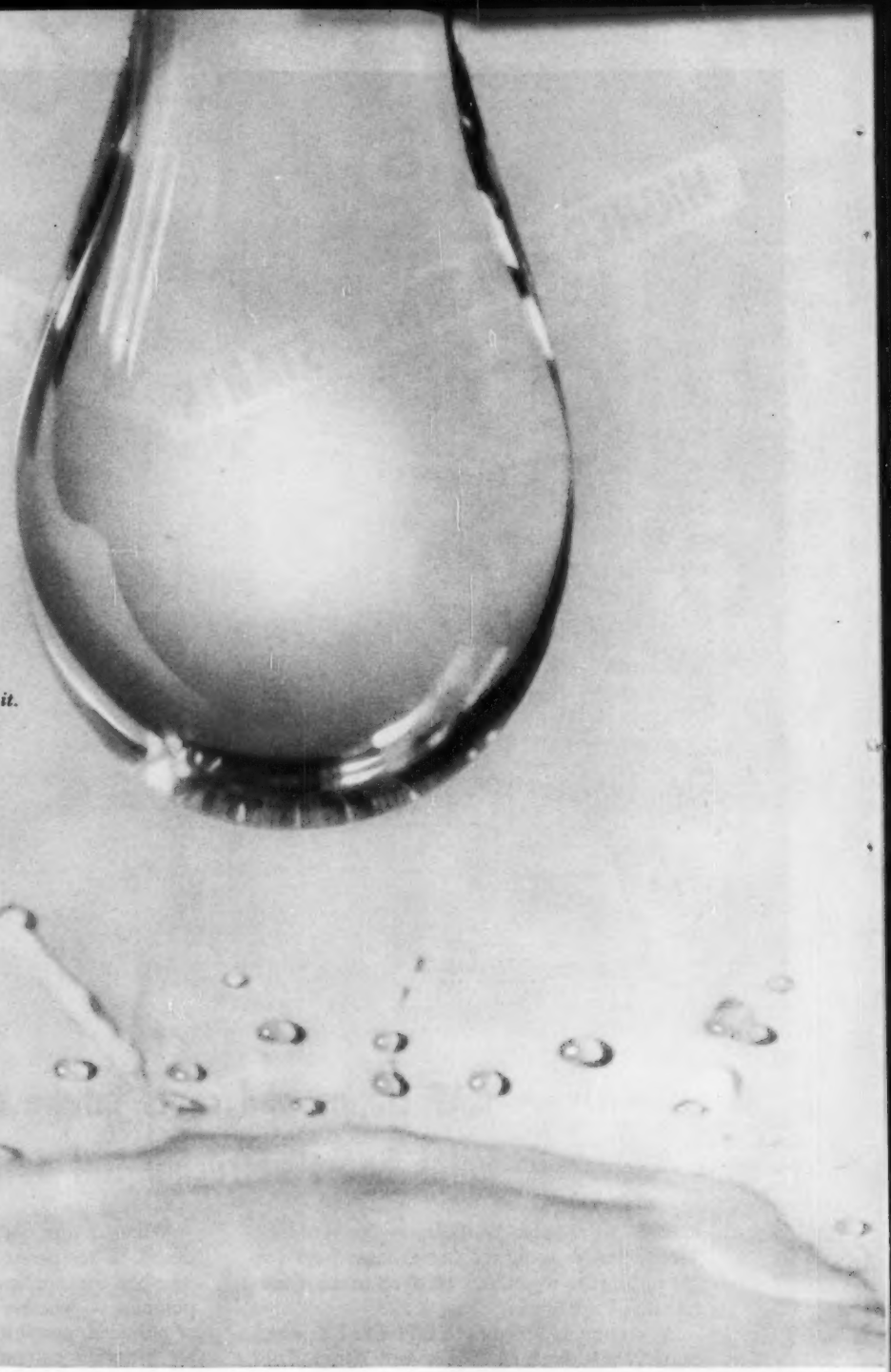
For information on AAF's complete line of BETTER AIR products for engines and compressors, write today for Bulletin 150. Address: Mr. Robert Moore, American Air Filter Co., Inc., 452 Central Avenue, Louisville, Kentucky.

AAF **American Air Filter**

BETTER AIR IS OUR BUSINESS

For more data on advertised products, use Readers' Service Cards, last page

water



comes in oceans, rivers, lakes, wells,
drops, buckets, pitchers and glasses.
it quenches thirsts, cooks food, puts
out fires, makes coffee and
brushes teeth. it spins mills,
runs electro-plants, cools motors
and power factories.
it spawns fish, sprinkles lawns,
floats boats, washes children
and grows flowers.

it sustains and nurtures.
it bends if you give it purpose.
it reshapes itself if you give it reason.
it is needed, wanted, feared,
praised and prayed for.

it is at the heart of all life.
it is in the arteries of all industry.
it is as close to us as skin
but as taken for granted as sky.

the end of water seems unbelievable.
if it is not on the horizon, it is just over it.
if it is not within sight,
it is just 'round the bend.
if it is not in the glass,
it is just in the spigot.

. . . this is the grand mirage . . .
the self-delusion that prevails
though the wells run low
and the streams go dry
and the water slips away.

we know water.
we know its ways.
we've learned its habits.
we've pulled it out of swamplands,
pushed it over mountains,
pumped it into deserts,
tunneled it through granite,
and rescued it from pollution.

above all else,
we know the need for it.
that is why,
for 130 years,
we've developed new uses for,
powered new factories with,
diverted the courses of
and jealously stood guard over
water.

Fairbanks, Morse

A MAJOR INDUSTRIAL COMPONENT OF FAIRBANKS WHITNEY CORPORATION, NEW YORK

No other manufacturer makes pumps for such a variety of hydraulic applications as Fairbanks, Morse. If it's liquid . . . if it flows . . . we make the pumps that move it . . . at low cost per gallon . . . in sizes from 200 gph to 800,000 gpm, and to 3000 psi . . . for every industrial need.

Our pumps . . . our generators and controls . . . our new rotary compressors . . . our drive toward better ways to de-salt ocean water . . . the potential of our advance Research & Development Center in Beloit . . . our lead position in the field of Hydrodynamics . . . all of these equip us to serve you.

Send for our brochure—"Hydrodynamics." Please write to Mr. Robert W. Kerr, President, Fairbanks, Morse & Company, 600 South Michigan Ave., Chicago 5, Illinois.

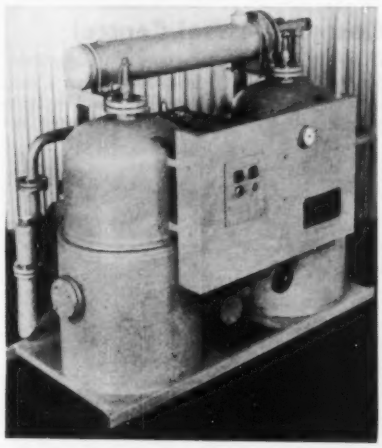
Equipment . . .

in a neat looking installation, whether the surface is left unfinished, or given a decorative or protective coating. Armstrong Cork Co.

Circle E5 green card, last page

Instrument Air Dryer

A new line of drying equipment for compressed air or other gases, has just been announced. Planned particularly for instrument air service, BZ Lectrodry-



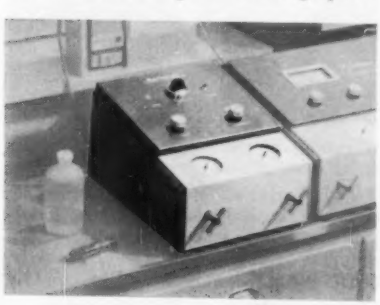
ers feature simplicity and modern, functional design. Parts are interchangeable, and the few moving parts are easily accessible, simplifying maintenance.

Operation is completely automatic. Working on a six-hour cycle, it adsorbs moisture, heats for regeneration and cools with no more attention than occasional lubrication. Adequate instrumentation permits checking the operation at a glance. Pittsburgh Lectrodryer Div., McGraw-Edison Co.

Circle E6 green card, last page

Hydrogen Flame Detector

The Hydrogen Flame Detector is an accessory designed to supplement the standard thermal-conductivity detector used in the GC-2 gas chromatograph.

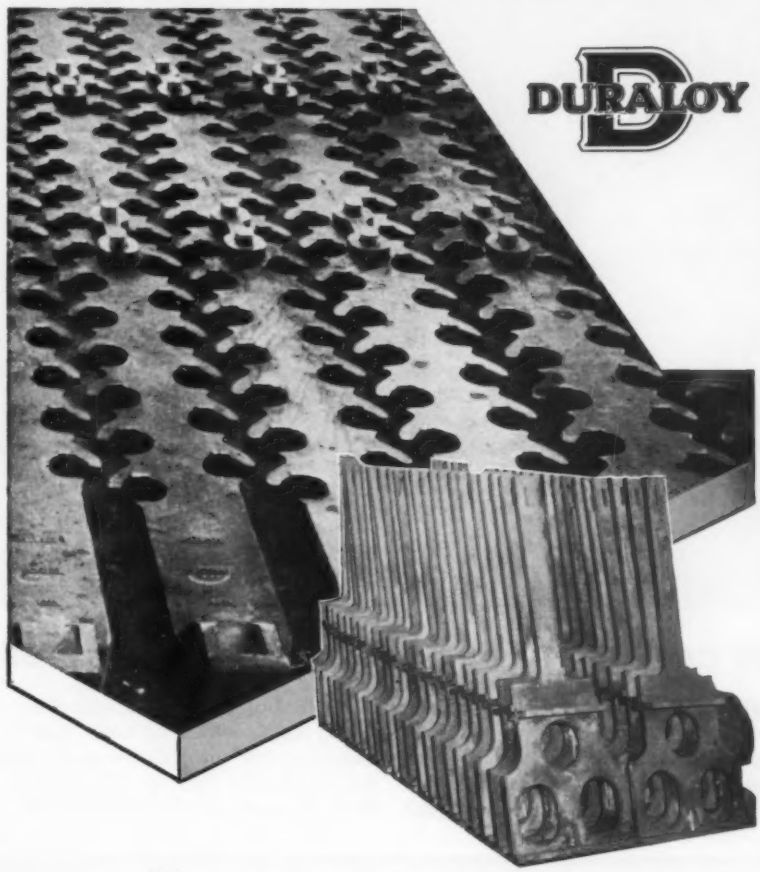


This ultrasensitive accessory, which has a typical sensitivity of 50 parts per billion full scale, is especially suited for detecting the presence of minute traces in complex organic compounds. Sensitivity depends to some extent on the com-

CORROSION RESISTANT

HEAT RESISTANT

Tube Supports



You can't buy Better Tube Supports . . . DURALOY Tube Supports are alloyed to meet individual corrosion and heat requirements. They are alloyed by experienced metallurgists and melted and cast by experienced high-alloy foundrymen, both groups with experience going back some thirty years. Castings are carefully tested in our own laboratories which are completely equipped for metallurgical, chemical and physical testing.

Many refineries have been DURALOY customers for years. Many refineries insist upon DURALOY castings. Whether it's straight production or engineering plus production, we are equipped to do the job. For more information, send for Bulletin No. 3150-G.

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OFFICE AND PLANT: Scottdale, Pa.

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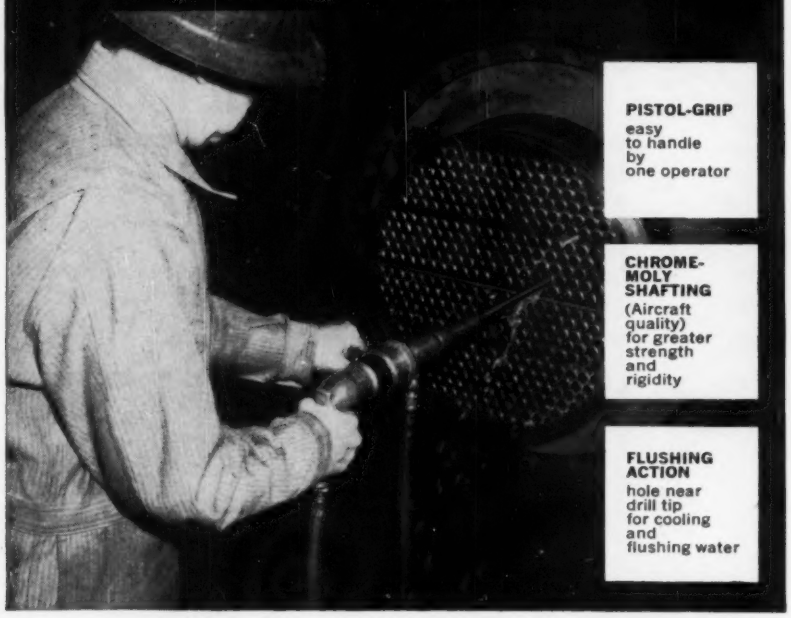
ATLANTA OFFICE: 76—4th Street, N.W.
CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

For more data on advertised products, use Readers' Service Cards, last page

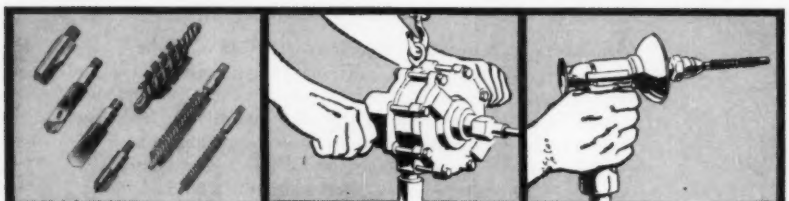
newest ELLIOTT tube cleaner

lightweight! air-driven!


PISTOL-GRIP
easy to handle by one operator
CHROME-MOLY SHAFTING
(Aircraft quality) for greater strength and rigidity
FLUSHING ACTION
hole near drill tip for cooling and flushing water

for condenser and heat exchanger tubes

Lightweight. Powerful. Air-driven. Trigger-action control with speed governor to prevent shaft-whip. High-speed motor reduced through planetary gears to 1500 rpm. Integral water-feeding attachment with finger-action valve which controls flow of cooling water into hollow shaft and drill or brush. Built-in oil reservoir. Send for tube cleaner bulletin Y-48.



DRILLS AND BRUSHES FOR VARIED NEEDS
Brushes for light deposits. Four types of drills clean light, hard-heavy, hard-light, and gummy deposits.

SUSPENSION TYPE
Air, steam or electric heavy-duty motor, for removing hard, heavy deposits. Ball bearings absorb thrust in either direction.

ELLIOTT JIFFY GUN
For extra-fast cleaning of light deposits in tubes ½ in. to 1¼ in. Air or water pressure shoots nylon brushes or rubber plugs through tubes.

ELLIOTT Company
Lagonda Plant—Springfield, Ohio

Y9-1

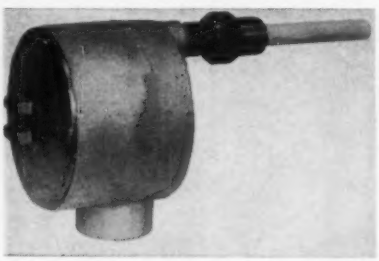
Equipment . . .

ponent being detected. In analyzing a typical C_6 component, the detector has a sensitivity of 1.5×10^{-13} moles per second full scale. Operating under identical chromatographic conditions, the Hydrogen Flame Detector will produce signals over 10,000 times greater than those of a conventional thermal conductivity cell. Beckman Scientific & Process Instruments Division.

Circle E7 green card, last page

Electronic-Level Control

The completely new transistorized Model B-07 Electr-O-Probe Level Control is a compact electronic level switch that has been thoroughly field tested to



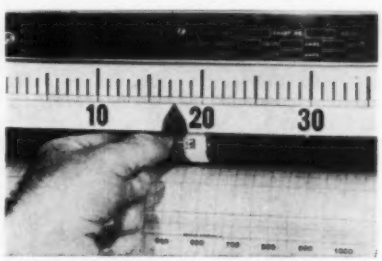
prove its suitability for high and low-level detection of liquids, granular solids, and liquid/liquid interfaces.

The outstanding feature of this model is the "solid state" circuit design which eliminates use of vacuum tubes and results in greater sensitivity and stability. Instruments, Inc.

Circle E8 green card, last page

Strip-Chart Recorder

A multipoint strip-chart recorder which can be easily converted to change the number of points being measured, the



actuation, or the range has been introduced.

The Universal Model 15 ElectroniK Recorder is designed for use in industrial processes where frequent record changing is required or where it may be desirable to change the type of primary element or range of measurement.

Applications of the recorder include spot-checking of boiler tube, gearing and transformer oil temperatures.

Measurements can be switched from 2 to 3, 4, 6, 8, 10, 12, 16, 20 or 24 points by simply changing a shorting plug and

How our small plant solved its waste disposal problem WITHOUT CAPITAL OUTLAY....

Pat. No. 2,900,096

DEMPSTER-DUMPMASTER Equipped Hauler Provides Containers and Service for Small Fee

Our small Midwestern manufacturing firm did not generate enough refuse to justify ownership of its own refuse disposal system. Yet, it was plagued by unsightly trash piles, fire hazards and scattered refuse in the plant yard.

Our plant engineer then heard of a DEMPSTER-DUMPMASTER equipped private hauler in the adjoining city. A survey revealed that two big-capacity refuse containers, placed one at each end of the plant, would handle the entire refuse accumulation.

The private hauler placed the containers, and a small monthly fee covered maintenance, labor, hauling and dumping refuse. No capital outlay was involved, disposal costs were reduced, and plant housekeeping was vastly improved.

In all major cities, private haulers who own DEMPSTER-DUMPMASTER equipment render fast, efficient, low-cost refuse storage and collection service. They place one or 100 containers at your service for a reasonable fee. A free brochure describes their service in detail.

Free Brochure and Name of Nearest Private Hauler on Request

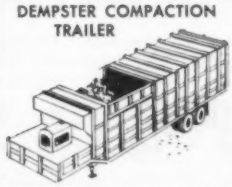
Dept. PE-4 DEMPSTER BROTHERS Knoxville 17, Tenn. Inc.

IN ALL LEADING CITIES FROM COAST TO COAST

DEMPSTER-DUMPSTER

DEMPSTER-DUMPMASTER

DEMPSTER COMPACTION TRAILER



DEMPSTER DUMPMASTER®

EQUIPPED PRIVATE HAULERS

appropriate indicating and prints wheels. Substitution of a new range card, terminal panel and scale changes actuation and range. Kits are available for point and for actuation and range change.

Universal models are equipped with measuring circuits for potentiometers or resistance thermometers mounted on interchangeable panels and zenor diode-regulated constant voltage units. Fixed cycle or synchro-balance printing models are available. Brown Instrument Div., Minneapolis-Honeywell Regulator Co.

Circle E9 green card, last page

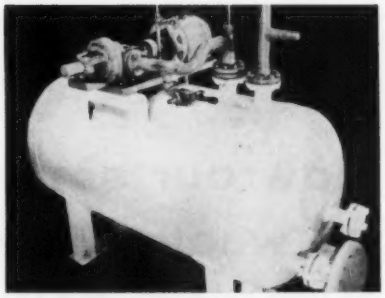
Fast TEL Unloading System

A vacuum pump system for unloading shipments of antiknock compounds at refineries, which will make possible faster unloading for many refiners, has just been announced.

The new system will be particularly valuable to refiners who desire faster unloading of antiknock compounds or whose unloading operations may be difficult due to their high-altitude locations or use of high-vapor-pressure gasoline stocks.

In either case, the pump produces a high vacuum which greatly facilitates the unloading operation.

The vacuum-pump system can be used



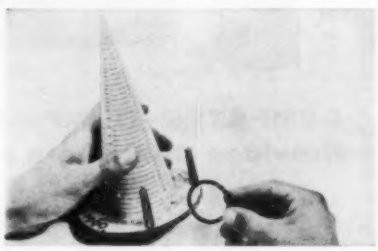
to unload any shipment of antiknock compound, ranging from a drum to a tank car or an Ethyl Sea-Land Tank. The system can be tied in with an existing TEL mixing plant at a refinery or built as part of a new plant.

The basic parts of the system are a vacuum pump with motor and a 300-gallon tank which is partially filled with a hydrocarbon sealant. The system, which guarantees a high-vacuum capacity under all conditions and has a high air-handling capacity, is economical to install and maintain, is simple to operate, and assures safe disposal of toxic fumes. Ethyl Corp.

Circle E10 green card, last page

Gage Checks O-Ring Size

A visual O-Ring size gage which enables O-Ring users to check I.D. and cross section of O-Rings without manual



or mechanical measuring has been developed.

The gage consists of a single-unit cone and base with adjustable cross section measuring strip. The cone is mounted on a slotted base. The I.D. of the O-Ring is measured by placing O-Ring on cone while the cross section is measured with slots in the base. Parker Seal Co. Div., Parker-Hannifin Corp.

Circle E11 green card, last page

LoCost Hi-Speed Computer

A new entry in the field of large-scale, high-speed electronic data processing equipment has just been introduced. The compact, transistorized system is capable of 45,000 floating-point operations per second. According to the manufacturer, it will offer versatility, expandability and high computing power at relatively low cost.

The new system has the ability to solve very large scientific and data processing problems at high speed, but with comparatively inexpensive equipment. A G-20

HOW MANY YEARS WILL A GOOD LINING LAST?

Make it with Hexmetal

AND DOUBLE THE NUMBER YOU FIRST THOUGHT OF

A lining lasts as long as its bonding properties.

The natural organic bond of refractory clays and the chemical set of concrete all fail eventually under the stresses imposed upon them. When a lining is "bonded" or given "bone" by Hexmetal Reinforcement, it holds in position long after all its natural bond is burnt out by heat or chemical action. The independent pinned joint of Hexmetal cells give twice the life of other reinforcements with lug joints.

Industry is year by year proving the value of these claims in Flues, Ash-Pits, Reactors, Cyclones, Cat Crackers, Coke Hoppers, Down Comer Pipes, Hydroformers, Water Turbine Flumes, Underground Galleries, etc.

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Hendrick Computer designed and rated perforated trays are setting new standards of higher capacity and economy throughout the entire petroleum and chemical processing industries.

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Hendrick is licensed to manufacture Esso "Jet-Trays", Socony "Uniflux", Shell "Turbo-Grid" and Stone and Webster "Ripple Trays" Hendrick is also equipped to supply all types of trays to specifications.

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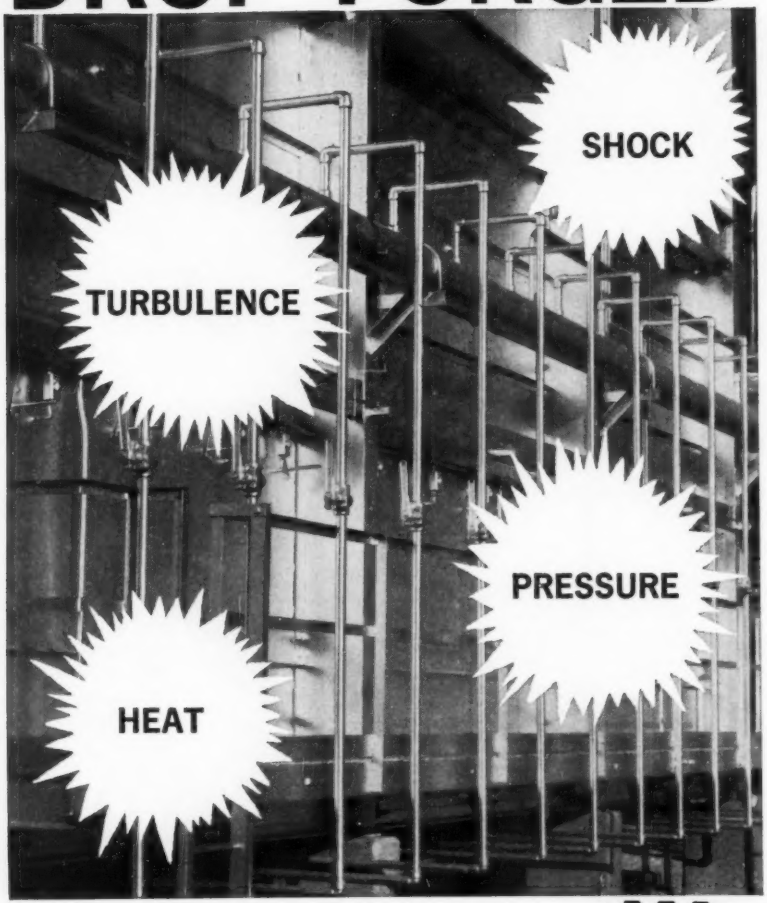
For more data on advertised products, use Readers' Service Cards, last page

DROP FORGED



For critical jobs, the brand to look for is W-S

When the piping application is most difficult, that's where you'll find W-S Forged Carbon Steel Fittings. Under the toughest conditions, these are dependable connections which stand up. Here's why:

- Drop forged for exceptionally high tensile and impact strength.
- Long, accurate threads, in perfect alignment.
- Uniform wall thickness, for safety.
- Accurate machining for tight fit.

For specifications and Distributor locations, write *Forge & Fittings Division, H. K. Porter Company, Inc., Box 95, Roselle, N. J.*

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PORTER SERVES INDUSTRY with steel, rubber and friction products, asbestos textiles, high voltage electrical equipment, electrical wire and cable, wiring systems, motors, fans, blowers, specialty alloys, paints, refractories, tools, forgings and pipe fittings, roll formings and stampings, wire rope and strand.

Equipment . . .

for scientific problems, leasing for less than $10,000 per month, is 100 times as fast as conventional computers in the same price class. Because it is all solid-state and highly automatic, operating costs are also quite low.

The complete line of input-output equipment offered includes magnetic tape units that read and write at 120,000 digits per second, and 600 to 1,250 line per minute printers. The fastest punched paper tape and card accessories available may also be used.

Physically, the G-20 is small compared with most large-scale data processing systems. Its central processor is only 66 inches wide, 60 inches high and only 28 inches deep. Built of solid-state components—5,000 transistors and 30,000 diodes—it has an expandable random-access magnetic-core memory which may consist of one to eight modules of 4,096 words each. Floating-point circuitry is standard equipment. Bendix Computer Div., Bendix Aviation Corp.

Circle E12 green card, last page

Fast Process Chromatograph

A new process chromatograph that features substantially faster analysis and automatic programming of up to eight streams has just been introduced.

The Type 26-212 process chromatograph makes analyses of liquids, gases, or vapors in 1/20th to 1/50th the time required by conventional chromatographs, depending upon the product. Many analyses take less than 30 seconds. This makes control of rapidly changing processes possible with a chromatograph for the first time.

Two separate units, control unit (left) and analyzer (right) both of which incorporate major improvements over earlier models, make up the chromatograph. The analyzer unit is housed in an explosion-proof housing for on-stream installation in hazardous areas. The control unit, which contains all operating controls and adjustments for the entire instrument, can be located on a control panel as far as 500 feet from the analyzer. A unique chromatograph package in the analyzer makes possible the faster speed. It consists of a small-volume pneumatic-

accuracy

ASHCROFT DURAGAUGES measure pressure with precise accuracy no matter how severe the conditions of service

Ashcroft Duragauges are available in pressure ranges from 15 psi (or vacuum) minimum to 100,000 psi. Dial sizes: 4½" through 12".

sustained

The Bourdon tube in Ashcroft Duragauges is manufactured to precision standards of flexibility and mono-linked to the rotary movement. When pressure flexes the tube, the gauge pointer is always positively positioned, because it is mounted on the geared center shaft of the movement. Sustained high accuracy and long life are assured.

Choose your Ashcroft Duragauges made of components best suited to your needs. Eight Bourdon tube materials are available. Movement of stainless steel with nylon bearings and pinion gear for longest wear. Case materials: special aluminum alloy or tough phenol plastic.

The unique "Maxisafe®" Duragauge provides absolute protection to the viewer, plus easy and quick access to the mechanism. Your industrial supply distributor will help you select the best combination of components for your Ashcroft Gauge requirements. Phone him today or write for Catalog 300B.

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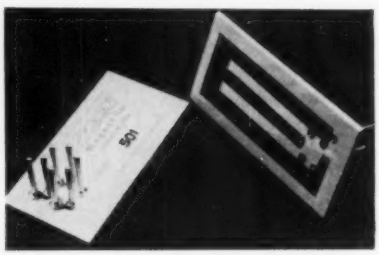
Equipment . . .

ally actuated sample valve, a small-bore packed column, and a fast-response detector. Consolidated Electrodynamics Corp.

Circle E13 green card, last page

Corrosion Indicators

A line of extremely sensitive "sensing elements" have been developed to detect corrosion of metal. They are called MagnaFilm Corrosion Indicators.



The essential element of the indicators is a vacuum deposited film of metal, 2 to 50 millionths of an inch thick. Special manufacturing techniques provide the ultra-sensitivity and reproducibility required to detect as little as five *billionths* of an inch of metal loss . . . sensitivity so great that the progress of corrosion is detected virtually atom by atom.

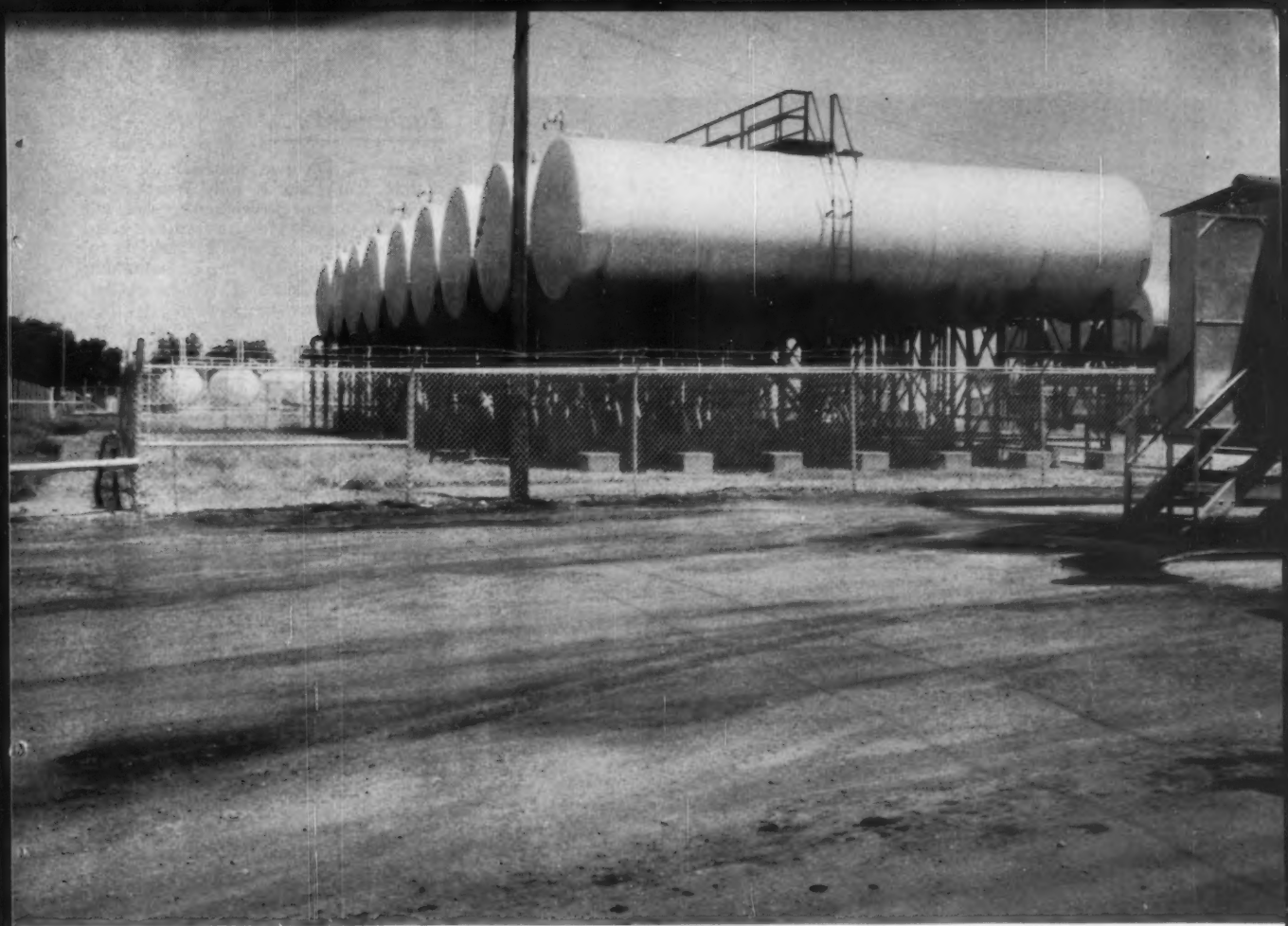
The Model 501 is designed for use with Crest Corrosometers in applications where it is desirable to establish approximate rates of corrosion. Crest Instruments.

Circle E14 green card, last page

Acid Reboiler Heater

A new tantalum bayonet heater has 124 square feet of heater area, and is composed of 52 tantalum tubes, 1½ inch OD by 72 inch length. It is designed

for use in a glassed-steel vessel being used as a nitric acid reboiler. Use of tantalum and glassed steel together is appropriate because the corrosion re-



• The Skelly Oil Company kept the area around these butane-propane storage tanks completely free of weeds for a whole season by spraying the ground with Du Pont "Telvar".

Get season-long control of fire-hazardous weeds —spray once with a Du Pont Weed Killer

No fire hazard here from weeds. No expensive or difficult weed-control program, either. Just a simple weed-control maintenance program with a Du Pont weed killer kept the area around these storage tanks clean. One spraying of Du Pont "Telvar" monuron or "Karmex" diuron weed killers provides safe, economical weed control around refineries, storage tanks, pipelines and producing fields for a season or longer. Fire hazards are eliminated.

Five-year records of several petroleum companies show that Du Pont "Telvar" and "Karmex" cut weed-control budgets from 50 to 75%. "Telvar" and "Karmex" are non-flammable, non-volatile, non-corrosive and low in toxicity to man and animals. Contact Du Pont for information on which weed killer is best suited to your soil type and moisture conditions—write Du Pont, 2543 Nemours Bldg., Wilmington 98, Delaware; in Canada: Du Pont of Canada Ltd., P. O. Box 660, Montreal, Quebec.

On all chemicals, always follow label instructions and warnings carefully.

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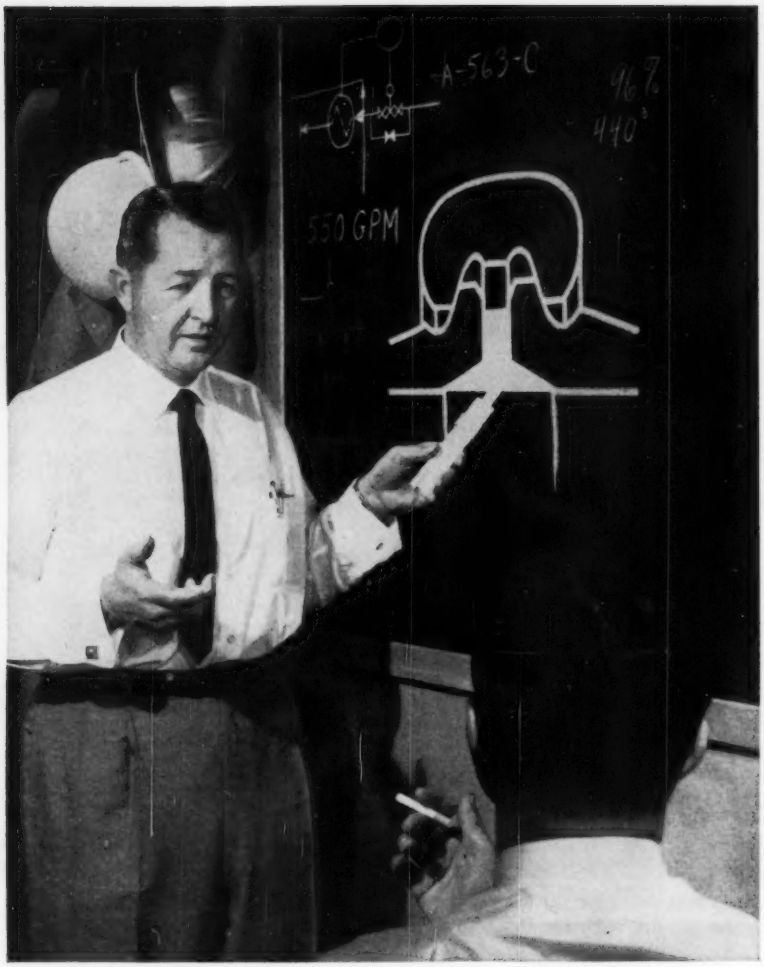
Weed and Brush Killers

TELVAR® monuron weed killer · **KARMEX®** diuron weed killer · **AMMATE® X** weed and brush killer · **TRYSBEN® 200** weed killer · **DYBAR®** fenuron weed and brush killer



New GRAYLOC® Seal Eliminates Leaks

GRAYLOC is practical where leakage is a problem, regardless of high or low pressure, where savings in money, space, weight or time are desirable.

The GRAYLOC seal design, a new principle in pipe connection, is simple: tapered lips on either side of a rigid rib. The seal lip tapers slightly less than the mating hub, forming a line seal as the components touch. As the connection bolts are tightened, the lips deflect to form a positive, leak-proof surface seal. GRAYLOC Connections can be made and released repeatedly and still operate to pressure without seal ring replacement.

GRAYLOC works in most flange applications. If you are interested in more information about how GRAYLOC can solve your leakage problems and save you money, write for the new GRAYLOC CATALOG on your company letterhead. No charge, no obligation.

GRAYLOC SALES DIVISION

GRAY *Tool Company*

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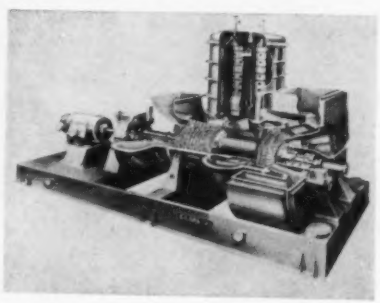
Equipment . . .

sistance of the two materials is very similar. Tantalum is fully resistant to all acids, except hydrofluoric; and—of particular importance—it is resistant even at elevated temperatures. In addition to its high resistance to corrosion, tantalum possesses the additional virtues of excellent heat transfer characteristics because of the thin wall sections that can be used—.015 in this application, and resistance to physical and thermal shock. The Pfaudler Co.

Circle E15 green card, last page

9,000 BHP Gas Turbine

A new open-cycle, single-shaft gas turbine with NEMA rating of 9000 bhp has just been introduced. It burns either liquid or gaseous fuels and is capable of



continuous operation under full-load conditions at normal rated speed of 5000 rpm. In applications requiring limited speed flexibility, the 305-S provides a low-cost, reliable source of rotative power for centrifugal compressors, power generators and liquid pumps.

The single-shaft design is ultra-simple with minimum number of parts. It provides high-rotating inertia and thereby insures minimum speed variations under transient load conditions. At rated speed, the axial compressor delivers a mass flow of 135 pounds per second. Turbine inlet temperature is held under 1,400° F to insure extra long life and a substantial margin of operating safety. The turbine is completely air cooled—pressurized air is bled off the axial compressor to cool high-temperature components, while cool air envelopes between inner and outer skin surfaces reduce heat loss and minimize external temperatures wherever possible. An optional air cooled lube oil cooler can be furnished to permit operation that is completely free of water requirements. Clark Bros. Co.

Circle E16 green card, last page

Bulletin Covers Tray Data

A new technical bulletin entitled "Glitsch V-1 Ballast Tray," has been released. It gives performance curves and detailed operating data on the company's new V-1 fractionating device, based on extensive laboratory tests conducted by Fractionation Research, Inc. According to the bulletin, these tests indicate the V-1 tray has a higher effi-

over multiple source buying of YOUR laboratory needs

Make Curtin your one reliable source for laboratory supplies. Complete stocks of quality laboratory equipment are maintained for immediate delivery at supply points strategically located in all major refining areas. Technical and Repair Services are readily available all the time to help with your specific problems. Call Curtin on your next laboratory order and get "everything at one source."

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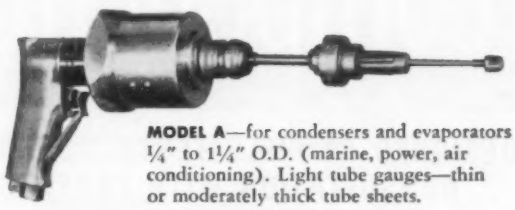
Now for every tube . . . every size . . . every type of job

WILSON
TORQ-AIR-MATIC
AUTOMATIC EXPANDER DRIVES AND ACCESSORIES

WILSON offers a complete line of Torq-Air-Matic automatic tube expander drives and torque controls. Wilson was the first to successfully develop an air driven tube expander drive that accurately controls tube expansion, by directly measuring torque output at the mandrel, without depending on frictional, ratcheting, magnetic, hydraulic or electrical devices. Hundreds are in successful use by many manufacturers and repair men the world over.



MODEL A—for condensers and evaporators ¼" to 1¼" O.D. (marine, power, air conditioning). Light tube gauges—thin or moderately thick tube sheets.

MODEL B—for heat exchangers ¾" to 1½" O.D. (oil refinery—chemical plants). Small boilers: heavy gauge tubes in thick sheets.

TUBE EXPANDERS—Wilson Models 41 and 44 Self-Feeding Tube Expanders are modern tube expanders for the *precision rolling* of condenser and heat exchanger tubes into the heavy tube sheets used in current practice.

TUBE CUTTER—Rugged and economical for use with a portable drill, for cutting off tube beyond the tube sheet.

TUBE PILOT—New Guide-Rite plastic guide inserted into tube end for easing tubes through sheet and support plates.

TUBE KNOCKOUT TOOLS—For hand or mechanical use.

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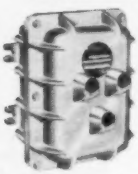
These features are the result: *All-aluminum* for non-magnetic, non-corrosive, lightweight design that offers faster heat dissipation. *Ribbed* for greater strength. *Rectangular design* for easier installation and maintenance, more compact assembly. *Ground surfaces* for tighter fit, no threads to strip. Front operation on all components.

PANEL BOARDS

To your specs, including breaker of your choice. Screw-cover or bolt-on cover, rectangular or "T" wiring trough. Available for hazardous as well as all-weather areas. All seals and connections included.

MOTOR STARTERS



Manual or magnetic, in many forms. Single speed, reversing, two speed, special, and combinations.

CIRCUIT BREAKERS

Through 800 amps, 1, 2, or 3 pole.

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Fuseable and non-fuseable, up to 200 amps.

CONTROL COMPONENTS— Push button stations, pilot lights, selector switches, contactors, relays, control transformers, lighting transformers, specials.

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Equipment . . .

ciency, greater flexibility, more usable capacity, and a flood capacity equal to the original A-1 Ballast Tray, a tray that when tested in late 1958 proved to be the most efficient device ever tested by the manufacturer for its intended use.

The ballast tray is a valve-type tray that utilizes two-stage vapor discharge units with single moving elements. These units position themselves initially on the tray for low to medium vapor rates and then are free to travel vertically to provide an increased orifice for very high vapor rates.

The bulletin explains that the high efficiencies obtained by the new tray are the results of the centripetal "fan-tail" mixing of the vapor and liquid. The vapor discharge orifice of each individual element is so shaped that the vena contracta at the vapor-liquid interface is amplified by the centripetal force of the vapor to produce extreme turbulence, greater interfacial area, and a more thorough mixing of the vapor with the liquid.

The operational curves and detailed data gathered by the manufacturer on the tray are for n-butane/iso-butane and n-heptane/cyclohexane systems. Fritz W. Glitsch & Sons, Inc.

Circle E17 green card, last page

Leak-Proof "Canned" Pump

A new seal-less (canned) centrifugal pump for the leak-proof handling of volatile, toxic, inflammable or other hazardous liquids has been announced.

Built in two sizes with 1 and 1¼ inch discharge, the pumps have a capacity range up to 110 gallons per minute, heads up to 100 feet and are recommended for handling clear liquids only. Cooling of the motor and lubrication of all parts is accomplished by circulating a controlled portion of the liquid being handled through the hermetically sealed rotor housing and the grooved bearings. All pumps are equipped with a built-in thermal cut-out device that protects the motor in the event motor winding temperature exceeds the maximum safe limit. Pumps are regularly supplied in 316 (CF8M) stainless steel but other materials can be furnished on application. Goulds Pumps Inc.

Circle E18 green card, last page

Gas Sampling Valve

One absolute must in gas chromatography is getting gas samples with reproducible volumes. If you're not sure just how big your sample is, there's a built-in error in any analysis. A solution to the problem is the new Gas-Sampling Valve.

Although the valve was developed to increase the accuracy of chromatographic analysis with such instruments as gas partitioners, it will be a boon to any gas-analysis system.

A handle controls two mechanically-linked 4-way valves whose Teflon plugs

New! RACKS FOR MOUNTING SPIN TOP® ENCLOSURES

For hazardous locations, you now can order Square D Spin Top enclosed starters completely wired and mounted on racks built to your specifications. Or we'll help you or your engineers design the racks. Either way, you get these advantages:

- Complete factory wiring and assembly
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- Choice of 4 sizes of Spin Top enclosures for circuit breakers and starters

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For almost every spraying application, there's a Spraying Systems Data Sheet that gives useful information on suggested installations and types of nozzles to use. If you have a problem, write and let us know the application involved . . . and we'll send the Data Sheet that applies.

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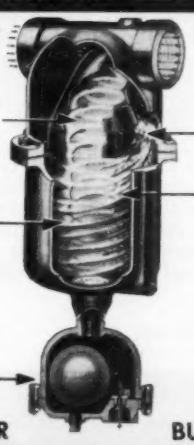
3283 RANDOLPH STREET • BELLWOOD, ILLINOIS

And . . . for complete spray nozzle information, write for Catalog 24.

NEW T TYPE SEPARATOR IMPROVED CYCLONE DESIGN

ASSURES MAXIMUM ENTRAINMENT SEPARATION


IN-LINE INSTALLATION
SCREWED OR FLANGED ENDS
LARGE, HI LEVEL OUTLET CHAMBER NO REENTRAINMENT PROBLEM
HI SPEED ENTRY— MAX. CENTRIFUGAL ACTION
CLEAN DESIGN PRODUCES MIN. PRESSURE LOSS
ENTRAINMENT HUGS WALL FLOWS TO BOTTOM DRAIN
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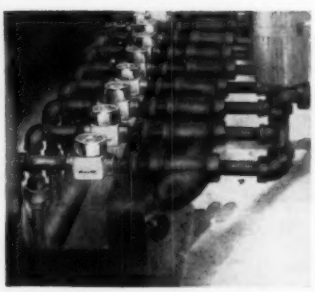
SARCO TOPICS

HOW TO SOLVE COMMON TRACER LINE PROBLEMS

How to cure water hammer with a steam trap that will operate in vertical position

Water hammer is an inherent problem in long tracer lines. So is freezing. Both problems can be overcome, and here's an example of how it has been done. At the Socony Mobil Oil Company's Paulsboro, N.J., refinery, they found that the Sarco Thermo-Dynamic Steam Trap, type TD-50, not only withstands water hammer, but installing the trap in a vertical position —which permits free drainage—presents no problems at all, thanks to its unique thermodynamic principle. In fact, 90% of the 250 TD-50's at this plant are vertically mounted. They never block heat transfer, and they remove condensate and air as fast as they collect.

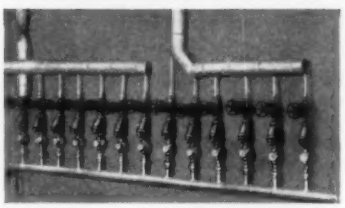
How to handle varied steam pressures — without adjustment



Can a trap — without adjustment — handle steam pressures that vary from 15 to 160 psi? Can the *same* trap vent air and drain condensate as rapidly as it is formed, be easy to install and require practically no maintenance at all? That was the problem set up by the engineering staff of Armour Chemical Division's McCook plant. They solved it by testing many traps. Their conclusion: Sarco TD-50 steam traps meet or beat their specifications, because:
they discharged condensate as fast as it formed, without wasting steam;
their compact inline construction made installation easy, even in tight quarters;
maintenance was practically negligible;
no adjustment was necessary for varying steam pressures. (In fact, the TD-50 is self-adjusting through its full operating range of 10-600 psi.)

No other steam trap can so adequately solve all these problems at one time.

How to be certain process fluid stays above 280° F. when outside temperature drops to −10° F.



The problem of maintaining design temperatures on tracer lines need not be difficult, no matter how extreme the conditions seem to be. For example, the tracer lines in a phthalic anhydride process at Witco Chemical Company's new Chicago plant had to be maintained above 280° F. Below this temperature, the chemical sets and the whole system would have to be taken apart and re-assembled. That's not all; ambient temperatures sometimes could drop to −10° F.

With reliability as a prime consideration, Scientific Design Company, Inc., who designed and constructed this brand new plant, selected the TD-50.

Because the TD-50 can be mounted vertically, freezing was no problem either. Added benefits that matter on tracer lines: the TD-50 is compact, light in weight, easy to install.

What is the most reliable tracer line trapping method to prevent unscheduled shutdown?

Particularly in refineries, steam traps have to function under exactly the kind of conditions that you'd expect to cause failure—they must function equally satisfactorily on low pressure or exhaust steam and on up through high-pressure, high temperature ranges. Not only that, but outside temperature may vary from subzero to subtropical. If maintaining design temperatures in your tracer lines appears to be hampered by these problems, consider how Phillips Petroleum Company, Kansas City, solved them. They found a trap which drains their tracer lines automatically over a full range of pressure, temperatures and loads. It's the Sarco TD-50 Steam Trap.

With only one moving part—a stainless steel disc, the TD-50 has little that can go wrong. In fact, it's so free of trouble that Phillips Petroleum Company consider their TD-50's as reliable and efficient as the piping. They now rely on 1800 of them throughout the plant. 1408

FOR FULL INFORMATION ON TRACER LINE TRAPPING or on any steam trapping problem—see your Sarco Sales Representative or write to

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New York 22, N. Y.
Plant: Bethlehem, Pa.

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SARCO

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Maintenance Time: 40 Seconds. If it now takes your maintenance crew more than a couple of minutes to service an ordinary trap, you're throwing away valuable time. This Sarco Thermo-Dynamic can be cleaned, blown out if necessary, and reassembled on the line in as little as 40 seconds.

For Prompt Information on the TD-50 . . . or for fast help on the efficient solution of any steam trapping problems, get in touch with a SARCO District Office, Sales Representative, or Distributor. (There's one near you.)

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make void-free seals at all 8 ports. Two ports are the inlet and outlet for the sample gas. Two are for the chromatographic carrier gas. The others connect with two loops of stainless-steel tubing, in which reproducible volumes of sample are automatically isolated.

With the handle at the right, the sample gas fills the left-hand loop. When the handle is moved to the left, the carrier gas flushes this first sample into the chromatographic system, at the same time that a new sample is filling the right-hand loop. Fisher Scientific Co.

Circle E19 green card, last page

Instrument Valve Manifold

A simpler and more dependable means of making instrument connections to flow meters, level indicators, and other types of instruments is now provided by a new instrument valve manifold.

The new manifold combines three valves in a single body—two providing suitable line shut-off and one that equalizes pressures to protect the instrument's internal working parts—together with a connection tap for calibration of the high-pressure side of the system.

The instrument valve manifold is furnished with either screwed or socket-weld end connections. Body and all working parts are of stainless steel. Yarnall-Waring Co.

Circle E20 green card, last page

Data Sheet On Angle Valve

Features and specifications of the unique No. 74 universal angle valve for liquid-level gages or instrument piping and general use are described and illustrated in new Data Unit No. 361. The advantages of a single-piece forged body and bonnet flange, simplified OS&Y bolted bonnet, and reciprocating stem are combined in one valve. Jerguson Gage & Valve Co.

Circle E21 green card, last page

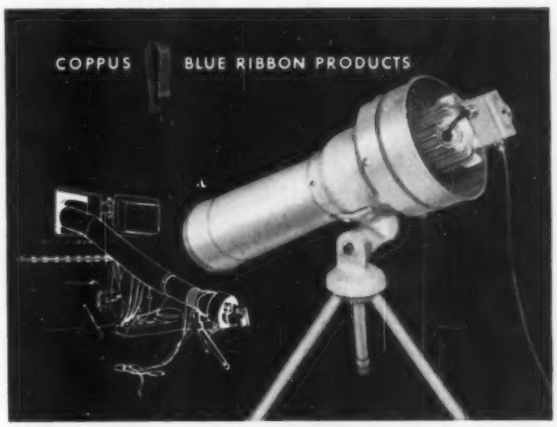
20-Page Valve Catalog

"Automatic Split-Body Control Valves and Accessories" is the title of a new catalog being offered.

Included in the 20-page publication is data on the new "S" and "Y" style split-body valves, each with its own angle variation. For the first time, conventional split-body valves, having actuators perpendicular to the pipe line, are offered along with "Y" type having actuators at a 45-degree angle to the pipe line.

Four double-page spreads are devoted to detailed specifications, data and dimensions of the various valve bodies with positioning piston actuators, on-off piston actuators, electro-hydraulic (Hydramotor) actuators and manual actuators. Electric gear-driven (Tork-Master) actuators and pneumatic diaphragm actuators are illustrated as optional modes of actuation.

By using the various tabulations, a



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Circle E22 green card, last page

Low-Cost Resuscitator

The first complete, low-cost oxygen-supplied rescue breather, named the "Samaritan," is a resuscitator-demand inhalator-aspirator.

When used as an oxygen resuscitator, the unit is not dependent on compressed oxygen as a source of power to operate a mechanical resuscitator valve. The Samaritan may be used as a mouth-to-mask resuscitator for continuing resuscitation after the oxygen cylinder is depleted and if a spare oxygen cylinder is not immediately available.

The device is a breathing assistor which may be used with or without oxygen to aid people who are having difficulty in breathing caused by asthmatic atacks or other illnesses; or by the inhalation of irritating gases.

It may be used as a demand inhalator for breathing patients after they have been resuscitated, but must be continued on oxygen. The patient receives oxygen at the rate he "demands". Globe Industries, Inc.

Circle E23 green card, last page

Stainless Pressure Gages

A line of drawn-case pressure gages with all components made of stainless steel has been announced. The new line will find use in services involving corrosive atmospheres and media.

Type 316 stainless-steel Bourdon tube, movement, socket (welded), case, and ring are incorporated in the design. The new gage meets ASA Grade B specifications—including an accuracy of 2 percent at the middle, or working half of scale (3 percent for the remainder).

The new stainless steel pressure gage is available in standard ranges up to 5,000 psi and in dial sizes of 2, 2½, and 3 inches. United States Gauge Div., American Machine & Metals, Inc.

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289b	290a	290b	291	292	293	294a	294b	295	296	297	299	300	301	302	303	304	305	306	307
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327	328	329	330	331	332	337	338	339	340	341	342	343	344	345	346	347	348	350	351a
351b	352	353a	353b	353c	353d	354	356a	356b	356a	356b	357a	357b	357c	361	362				

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327	328	329	330	331	332	337	338	339	340	341	342	343	344	345	346	347	348	350	351a
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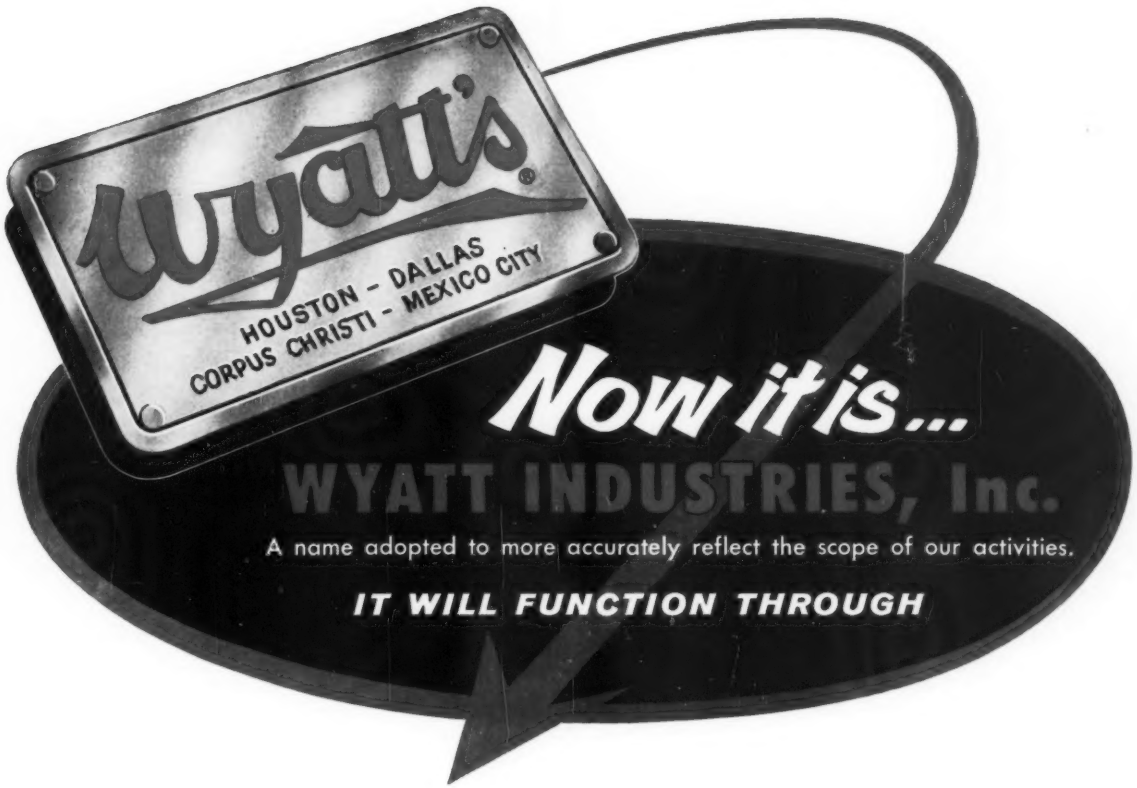
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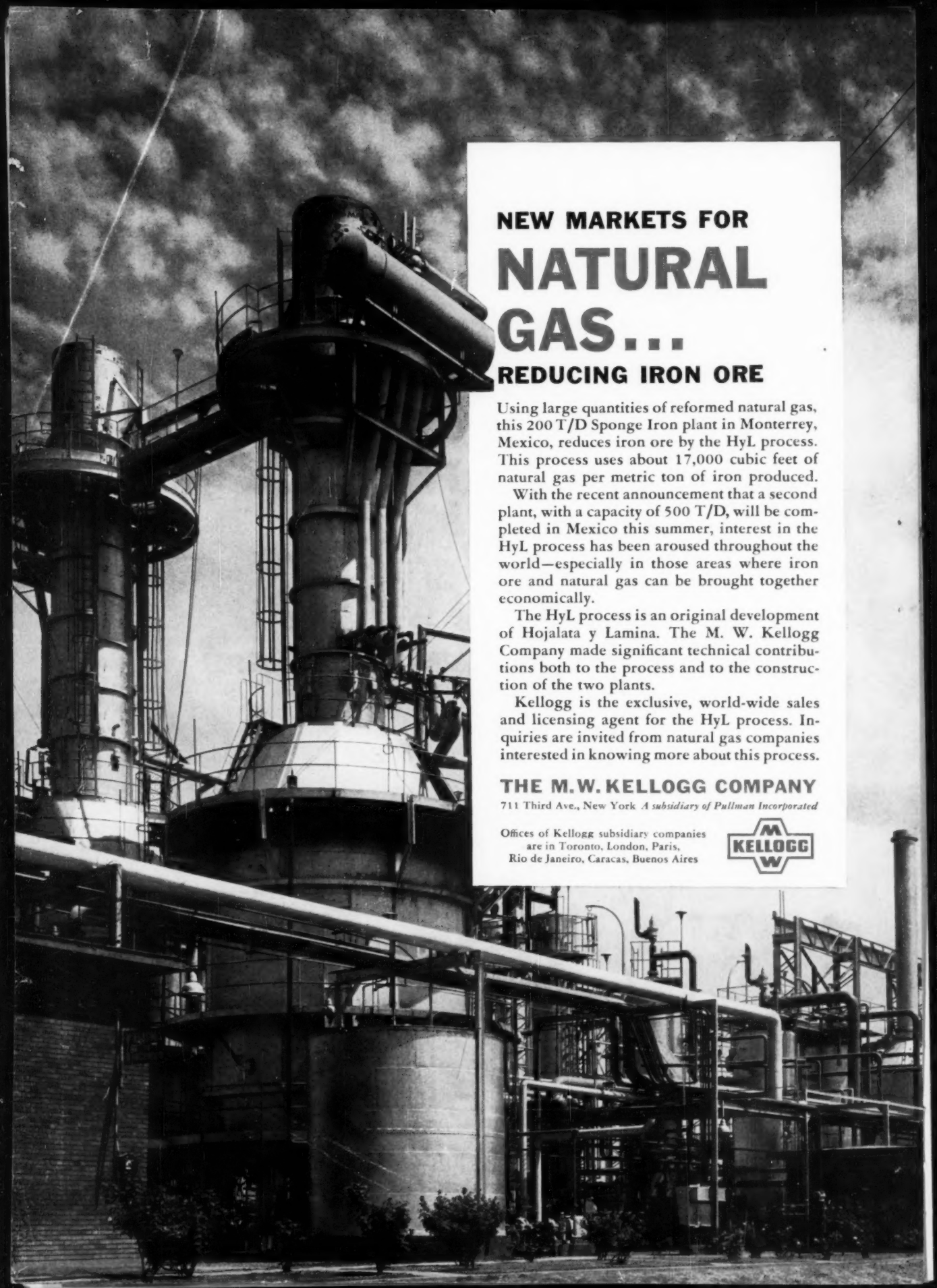

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